FM/AM SIGNAL GENERATOR

TF 995A/2M

OPERATING AND MAINTENANCE HANDBOOK

MP MASTER
MA23716

MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND

AMENDMENTS, where applicable, are included at the end of the handbook.

OPERATING
AND
MAINTENANCE
HANDBOOK
No. OM 995A/2M

F.M./A.M. Signal Generator

TYPE TF 995A/2M

(*Serial Nos. JA310/001 and above*)

MARCONI INSTRUMENTS LTD., ST. ALBANS, HERTS., ENGLAND

C.P. 5c 6/62/C

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OM 995A/2M
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Contents

Section		*Page*
	DATA SUMMARY	4
	SCHEDULE OF PARTS SUPPLIED	5
1	**INTRODUCTION**	7
2	**OPERATION**	7
2.1	INSTALLATION	7
2.2	SWITCHING ON AND WARMING UP	7
2.3	CONNECTING TO EQUIPMENT UNDER TEST	7
2.4	TUNING	8
2.4.1	General	8
2.4.2	Crystal Calibrator	9
2.4.3	Incremental Frequency Control	10
2.4.4	Interpolating Dial	10
2.5	SETTING UP FOR C.W. OR MODULATED OUTPUT	11
2.5.1	Continuous Wave	11
2.5.2	Amplitude Modulation	12
2.5.3	Frequency Modulation	13
2.5.4	Simultaneous A.M. and F.M.	15
2.6	R.F. OUTPUT ARRANGEMENTS	15
2.6.1	Outputs from 1 μV to 100 mV at 52 and 75 ohms	15
2.6.2	Outputs from 2 μV to 200 mV at 75 ohms only	16
2.6.3	Outputs from 0·1 μV to 10 mV at 52 and 75 ohms	16
2.6.4	Output in terms of voltage developed across external load	17
2.6.5	Matching to external loads other than 52 or 75 ohms	17
2.6.6	Matching to balanced loads	19
2.7	SYNCHRONIZING SIGNAL	19
3	**OPERATIONAL SUMMARY**	20
4	**TECHNICAL DESCRIPTION**	21
4.1	R.F. CIRCUITS	21
4.2	MODULATION SYSTEMS	22
4.3	MONITORING ARRANGEMENTS	22
4.4	POWER UNIT	22
5	**MAINTENANCE**	23
5.1	GENERAL	23
5.2	REMOVAL OF CASE	23
5.3	MAINS INPUT ARRANGEMENTS	23
5.4	ACCESS TO ENCLOSED SUB-ASSEMBLIES	24
5.4.1	R.F. Unit	24
5.4.2	MULTIPLY BY Attenuator	24
5.4.3	OUTPUT VOLTAGE Attenuator and Monitor Crystal X2	24
5.4.4	Mains Input Filter Unit	25
5.4.5	Power Unit	25
5.5	WORKING VOLTAGES	25
5.6	REPLACEMENT OF VALVES AND CRYSTALS	25
5.7	PRESET AND SPECIALLY SELECTED COMPONENTS	27

Section		*Page*
5.8	SCHEDULE OF TESTS	28
5.8.1	Apparatus Required	28
5.8.2	Insulation	28
5.8.3	Hum Level	28
5.8.4	Crystal Oscillator	28
5.8.5	Basic Oscillator	28
5.8.6	Frequency Multipliers	28
5.8.7	1·5- to 13·5-Mc/s Band	29
5.8.8	R.F. Output Voltage Accuracy	29
5.8.9	Modulation Oscillator	29
5.8.10	F.M. Distortion	29
5.8.11	Deviation Range Adjustments	30
5.8.12	F.M. Deviation	30
5.8.13	Incremental Frequency	31
5.8.14	Deviation Monitor Circuit	31
5.8.15	High Deviation	31
5.8.16	External F.M.	31
5.8.17	Internal A.M.	32
5.8.18	External A.M.	32
5.8.19	Spurious A.M.	32
5.8.20	Spurious F.M. on C.W.	32

6	**COMPONENT LAYOUT ILLUSTRATIONS**	
	FRONT PANEL	Fig. 6.1
	GENERAL UNDERSIDE VIEW FROM REAR (CASE REMOVED) ...	Fig. 6.2
	L.F. AND R.F. UNITS (TOP VIEW WITH R.F. UNIT SCREENING COVER REMOVED)	Fig. 6.3
	R.F. UNIT (GENERAL UNDERSIDE VIEW)	Fig. 6.4
	R.F. UNIT (CLOSE-UP OF PORTION OF UNDERSIDE)	Fig. 6.5
	L.F. UNIT (UNDERSIDE VIEW)	Fig. 6.6
	ATTENUATORS (COVERS REMOVED)	Fig. 6.7
	POWER UNIT	Fig. 6.8
7	**SPARES ORDERING SCHEDULE**	SOS 1
8	**CIRCUIT DIAGRAMS**	
	R.F. and L.F. Units	Fig. 8.1
	Power Unit	Fig. 8.2
	DECIBEL CONVERSION TABLES	

Data Summary

Frequency

RANGE: 1·5 to 220 Mc/s in five bands:
1·5 to 13·5 Mc/s, 13·5 to 27·5 Mc/s, 27 to 55 Mc/s, 54 to 110 Mc/s, 108 to 220 Mc/s.

CALIBRATION ACCURACY: From 1·5 to 13·5 Mc/s the frequency calibration has an average accuracy of 3%. From 13·5 to 220 Mc/s the calibration of the main frequency dial is accurate to within 1%. In addition, the built-in crystal calibrator provides 14 check points to an accuracy of 2 parts in 10^4, on each of the four higher-frequency bands.

INCREMENTAL CONTROL: The cover of this control is as follows:—
± 50 kc/s on band 2,
± 100 kc/s on bands 1 and 3,
± 200 kc/s on band 4,
± 400 kc/s on band 5.
The calibration is accurate to within 10%.

Output

VOLTAGE: Built-in coarse and fine 75-ohm attenuators connected in cascade provide—in conjunction with the 6-dB Terminating Unit—a source e.m.f. variable in 2-dB steps from 1 μV to 100 mV. Interpolation between the 2-dB steps is by means of a ± 1 dB calibration on the r.f. level meter.

HIGH OUTPUTS: Source e.m.f.'s up to 200 mV at an impedance of 75 ohms are obtained direct from the Generator output cable.

LOW OUTPUTS: Source e.m.f.'s down to a nominal 0·1 μV at impedances of 75 and 52 ohms are obtained by inserting 20-dB Attenuator Pad TM 5552 between the Generator output cable and the Terminating Unit.

ACCURACY: The accuracy of the joint indication of the attenuators and level meter is within 1 dB ± 0·25 μV up to 100 Mc/s, and within 2 dB ± 0·25 μV up to 220 Mc/s.

Modulation

F.M.: Normal deviation continuously variable from 0 to 25 kc/s and 0 to 75 kc/s on all bands; the accuracy at maximum deviation at 1000 c/s is ± 5% of f.s.d., with a possible additional variation of ± 10% due to valve ageing or random replacement.
High deviation of ×2 normal is also available on bands 1 and 3, ×4 normal on band 4, and ×8 normal on band 5.
Internal modulation at 1000 c/s, with modulation distortion not exceeding 2% at maximum deviation. External modulation characteristic flat within 1 dB, 50 c/s to 15 kc/s, with respect to 1000 c/s.

SPURIOUS F.M. ON C.W.: At carrier frequencies below 100 Mc/s the spurious f.m. due to hum does not exceed 50 c/s deviation; at frequencies between 100 Mc/s and 220 Mc/s it does not exceed 100 c/s deviation.

A.M.:	Internal at 1000 c/s to a depth variable up to 50%, with distortion not exceeding 6% at 30% depth. External modulation characteristic flat to within 1 dB, 50 c/s to 10 kc/s.
SYNCHRONIZING SIGNAL:	A nominal 100-volt high-impedance output from the internal 1000-c/s oscillator is available at the front panel.
Power Supply:	200 to 250 volts, or 100 to 150 volts after adjusting internal link, 40 to 65 c/s; 65 watts. Both the mains and h.t. circuits are fused.

Dimensions and Weight:

Height	*Width*	*Depth*	*Weight*
13 in (33 cm)	17½ in (44 cm)	8½ in (22 cm)	33 lb (15 kg)

Schedule of Parts Supplied

The complete equipment comprises the following items:—

1. One F.M./A.M. Signal Generator Type TF 995A/2M complete with valves, etc., as under:—

Valves:	One:	OA2 (150C4), Voltage Stabilizer Tube.
	One:	5Z4G (52KU), Full-Wave Rectifier.
	Six:	6AK5 (EF95), Pentodes.
	Two:	6AK6, Pentodes.
	Two:	6AL5 (D77), Double Diodes.
	One:	6AU6 (EF94), Pentode.
	One:	12AT7 (ECC81), Double Triode.
	One:	5651 (QS83/3), Voltage Reference Tube.
Lamp:	One:	6·3-volt, 0·3-amp, M.E.S., Pilot Lamp.
Fuses:	Two:	2-amp, Belling-Lee Type O cartridge fuses, for 200- to 250-volt operation. (For 100- to 150-volt operation, the 2-amp fuses are replaced by a similar type having a rating of 3-amps.)
	One:	150-mA, Beswick Type TDC11 Surge-Resisting cartridge fuse.
Oscillator Crystal:	One:	333·3 kc/s, Marconi Type 1655C.
Semiconductor:	One:	Type CS2-A Silicon Diode.

2. One Terminating Unit Type TM 5551; 75 ohms in, 52 and 75 ohms out.

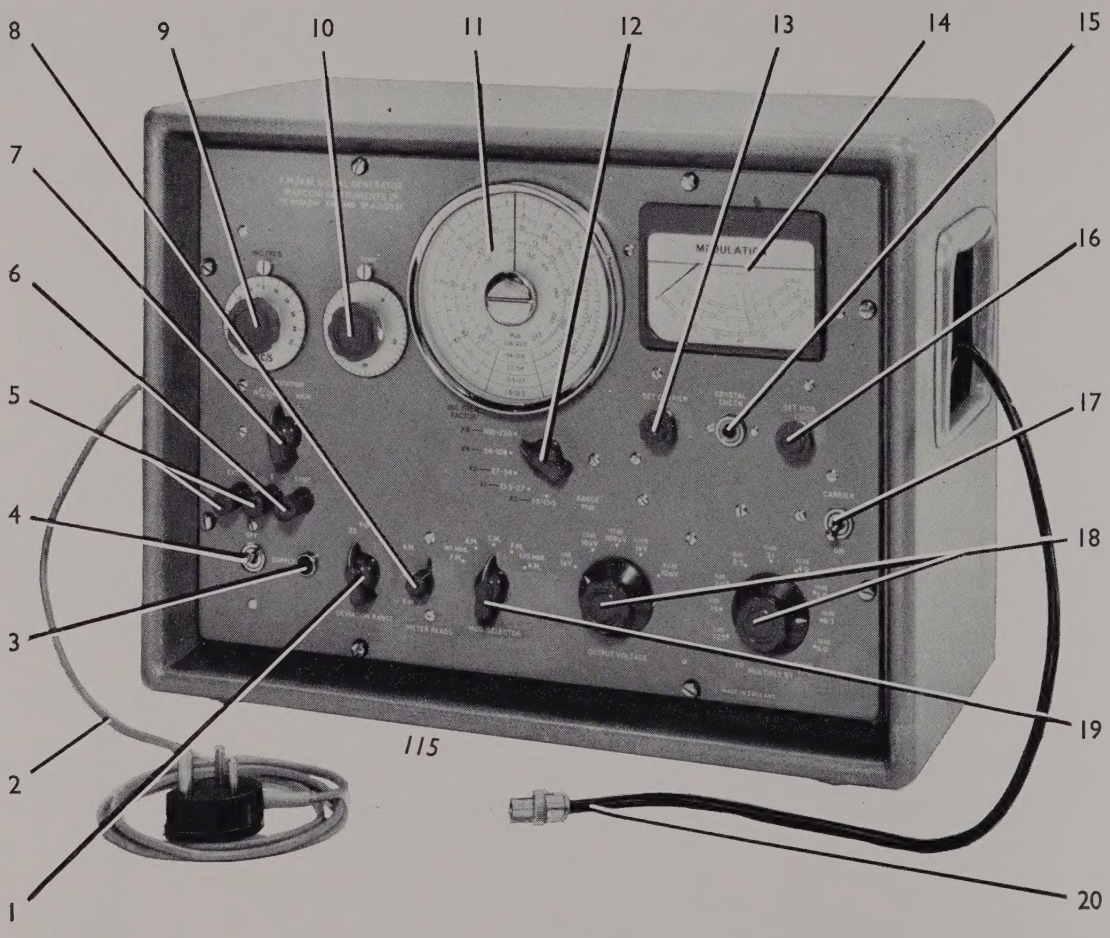
3. Two Coaxial Free Plugs, Type BNC; one 50-ohm, one 75-ohm; for Terminating Unit outlets.

4. One Telephone Plug, S.T.C. Type 4006; for Crystal Check jack.

5. One Operating and Maintenance Handbook No. OM 995A/2M.

The following accessory is an optional item supplied only if specially ordered:—

20-dB Attenuator Pad Type TM 5552; for use between output cable and Terminating Unit.



1. **Deviation Range Selector**
   Read deviation from corresponding scale on meter
2. **Mains Lead**
3. **Pilot Lamp**
4. **Mains Supply Switch**
5. **External Modulation Input** for f.m. or a.m.
6. **Sync Output** from internal modulation oscillator
7. **Normal:** deviation is as shown on meter
   High: multiply meter reading by factor on Range switch
8. **Meter Function Selector**
9. **Incremental Tuning Control**
   Carrier shift is given by dial reading multiplied by factor on Range switch
10. **Main Tuning Control**
11. **Main Tuning Dial**
    Knurled boss adjusts cursor to standardize scale against crystal check points
12. **Range Selector**
13. **Set Carrier Control**
    For adjusting unmodulated carrier to Set R.F. mark on meter
14. **Meter** indicates carrier level, f.m. deviation, or a.m. depth depending on setting of Meter Reads switch
15. **Crystal Check Jack**
    Plug in headphones here to switch on crystal check oscillator
16. **Set Mod Control**
    Adjusts f.m. deviation or a.m. depth
17. **Interrupts Output** without switching off filaments
18. **Output Attenuators**
    Direct reading in source e.m.f. at output of Terminating Unit when carrier is adjusted to Set R.F. mark on meter
19. **Modulation Selector**
20. **Output Lead** (75Ω)
    BNC socket type UG-261B/U

Fig. 2.1 *Controls.*

1 Introduction

The TF 995A/2M Generator delivers a.m. and f.m. signals in the range 1·5 to 220 Mc/s.

Its output is continuously variable from 1 μV to a maximum of 100 mV at 52 ohms and 200 mV at 75 ohms; and by using an optional 20-dB pad, the minimum can be extended down to 0·1 μV.

Modulation, obtained either from an internal 1000-c/s oscillator, or from an external source, is variable to maximum deviations ranging from 25 to 600 kc/s for f.m. or to depths up to 50% for a.m.

This generator provides comprehensive test and alignment facilities for a.m. and f.m. receivers in the v.h.f. and h.f. bands. It has crystal check points for accurate calibration of tuning dials, slow-motion drive and direct-reading incremental tuning for precision bandwidth measurements, monitored f.m. deviation and a.m. depth for signal-to-noise measurement, and simultaneous f.m. and a.m. for limiter and discriminator testing.

2 Operation

2.1 INSTALLATION

Unless otherwise specified, the Signal Generator is normally dispatched with its valves in position and with its mains input circuit adjusted for immediate use with a 240-volt, 40- to 65-c/s mains supply. The instrument can be adjusted for operation from any other 40- to 65-c/s supply voltage in the ranges 200 to 250 and 100 to 150 volts. To check or alter the settings of the mains transformer tappings, refer to MAINTENANCE, Section 5.3.

2.2 SWITCHING ON AND WARMING UP

Before switching on, be quite sure that the instrument is correctly adjusted to suit the particular mains supply to which it is to be connected. Then proceed as follows:—

(1) Connect the mains lead—stowed in the left-hand case-handle recess—to the mains supply socket.

(2) Switch ON by means of the SUPPLY switch; the red pilot lamp should now glow.

(3) Before proceeding further, allow a short time —say five minutes—to elapse for the internal circuits to warm up. If a particularly high standard of frequency stability is required, this time should be increased to about 30 minutes.

2.3 OUTPUT CONNECTIONS

The r.f. output from the Signal Generator is derived, at a source impedance of 75 ohms, via a permanently attached coaxial lead fitted with a BNC free socket; the lead is stowed in the right-hand case-handle recess.

The TERMINATING UNIT, which will normally be plugged on to the output lead, has two outlets, one of 75 ohms impedance and the other of 52 ohms. Two free plugs are supplied for making connection to the Terminating Unit outlets.

The 20-dB ATTENUATOR PAD, available as an optional accessory, can be inserted between the Generator output socket and the Terminating Unit input plug when low outputs are required.

Details on the use of the Terminating Unit and Attenuator Pad are given in Section 2.6, R.F. OUTPUT ARRANGEMENTS.

Equivalents to the free plugs supplied, and illustrated in Fig. 2.2, are as follows:—

	75 ohm	*50 ohm*
Great Britain,		
Air Ministry:	10H/20946	10H/20935
Films and Equipment:	UG-260/U	UG-88/U
Transradio Ltd.:	BN. 1/7	BN. 1/5
Belling and Lee:		L. 1331/FP
United States,		
Military No.:	UG-260/U	UG-88/U

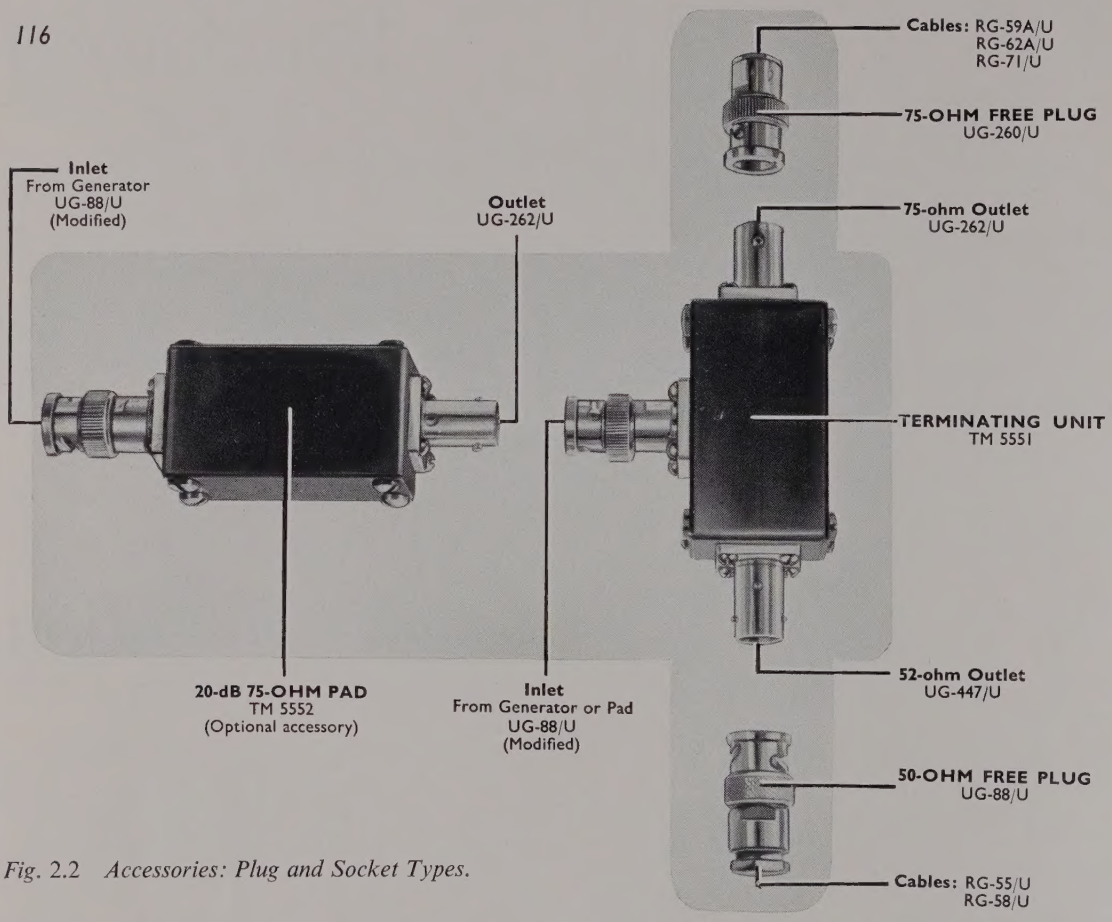


Fig. 2.2 Accessories: Plug and Socket Types.

2.4 TUNING

The various aspects of tuning the Generator are dealt with in the following sections.

General tuning: Section 2.4.1.

Standardizing frequency against crystal oscillator: Section 2.4.2.

Use of incremental frequency controls: Section 2.4.3.

Interpolation of main frequency scales: Section 2.4.4.

2.4.1 GENERAL TUNING

The TF 995A/2M covers the range 1·5 to 220 Mc/s in five bands as follows:—

1·5 to 13·5 Mc/s
13·5 to 27·5 Mc/s
27 to 54 Mc/s
54 to 110 Mc/s
108 to 220 Mc/s

The particular band required is selected by means of the RANGE switch. Rotation of the TUNE control varies the output frequency within the limits of the band selected, and moves the main dial relative to its cursor.

The Signal Generator has a built-in crystal calibrator, and the cursor of the main tuning dial is mounted so that its angular position relative to that of the dial is variable over a small arc by movement of a milled boss at the centre of the dial. This movable cursor enables the operator to standardize the frequency scale of the Signal Generator at any time; the cursor is used in conjunction with the crystal calibrator in the manner described in Section 2.4.2.

In addition to the RANGE switch and the TUNE control, the instrument is fitted with a directly calibrated incremental frequency control; the method of using this control is described fully in Section 2.4.3. Section 2.4.4 deals with the method of interpolating between main dial markings by means of the linearly calibrated dial on the TUNE control.

2.4.2 USE OF THE CRYSTAL CALIBRATOR

(a) Introduction

The calibrator, or crystal oscillator, has a fundamental frequency of 333·3 kc/s, with an accuracy of 2 parts in 10^4, and is coupled to the basic 4·5- to 9·16-Mc/s r.f. oscillator which feeds the multiplier chain. Plugging a pair of high-resistance head telephones into the CRYSTAL CHECK jack socket automatically brings the calibrator circuit into use; with the aid of the headphones, the difference frequency between the basic oscillator and the harmonic multiples of the calibrator's 333·3 kc/s can be monitored aurally.

Because the outputs on the four higher-frequency bands are all derived directly from the multiplier chain, their frequencies have an exact integral relationship to the frequency of the basic oscillator. It follows, therefore, that setting the TUNE control to bring the basic-oscillator frequency to that of a crystal harmonic will also bring the frequency of the outputs from the multiplier chain to a known relationship with the crystal harmonic, and allow the frequency dial to be standardized with a high degree of accuracy.

Outputs on the lowest-frequency, 1·5- to 13·5-Mc/s, band are not derived directly from the multiplier chain; their generation involves a heterodyne action between the 27- to 54-Mc/s multiplier and a 30-Mc/s fixed oscillator which is not locked to the basic oscillator. For this reason, although use is made of the crystal calibrator when setting up for 1·5- to 13·5-Mc/s outputs, the accuracy of standardization is of a lower order than that obtained on the four higher-frequency ranges.

(b) Check-Point Frequencies

The calibrator provides a total of 56 check points between 13·5 and 220 Mc/s; these check points occur as follows:—

13·5–27 Mc/s band: At 14, 15, and 16 Mc/s, and every calibration point which is a multiple of 1 Mc/s, to 27 Mc/s.

27–54 Mc/s band: At 28, 30, and 32 Mc/s, and every calibration point which is a multiple of 2 Mc/s, to 54 Mc/s.

54–108 Mc/s band: At 56, 60, and 64 Mc/s, and every calibration point which is a multiple of 4 Mc/s, to 108 Mc/s.

108–220 Mc/s band: At 112, 120, and 128 Mc/s, and every calibration point which is a multiple of 8 Mc/s, to 216 Mc/s.

(c) Standardization Procedure

As shown above, the calibrator allows the frequency scale to be checked at 14 different points on each of the above bands, and the adjustable cursor can be set to correspond exactly with any one of these points.

When the Signal Generator is to be used above 13·5 Mc/s to provide an output at a single spot frequency, or over a narrow band of frequencies, the cursor should be set up at the nearest crystal check point.

When the Signal Generator is to be used over a wide range of frequencies, and it is inconvenient to reset the cursor for each material frequency change, or, alternatively, when using the 1·5- to 13·5-Mc/s band, the procedure is varied to reduce the mean error to a minimum. The method of standardizing the frequency scale for subsequent general use is as follows:—

(1) Set the INC. FREQ. control to zero.

(2) Set the RANGE switch to 13·5–27 Mc/s.

(3) Using the headphones plugged into the CRYSTAL CHECK jack, tune the main dial to a crystal check point near the centre of the band; e.g. 20 Mc/s.

When using the calibrator, the MOD SELECTOR must be set to a position other than INT MOD—F.M. or EXT MOD—F.M. This ensures that the variable oscillator is not being frequency modulated—a condition which prevents precise setting of the TUNE control for the lowest-frequency beat note in the headphones, since it gives rise to a fluctuating tone.

After using the calibrator, the Signal Generator can, of course, be subsequently set up for f.m. without invalidating any frequency calibration previously given by use of the calibrator.

(4) Adjust the milled boss in the centre of the dial to bring the cursor exactly in line with the calibration mark corresponding to the crystal check point.

If the Signal Generator has been out of use for some time, it may be necessary to use a coin in the slot provided in order to rotate the milled boss.

(5) Check the calibration accuracy at several crystal check points both above and below the check point at which the cursor was set in (4) above.

(6) Readjust the cursor setting to equalize the errors over the band; e.g. it might be found that, with the frequency scale indication correct at 20 Mc/s, the indication was high at both 15 and 25 Mc/s —in such a case, the errors would be equalized by making the indication a little low at 20 Mc/s, and thus not so high at 15 and 25 Mc/s.

It will be noted that, in the above procedure, the frequency scale is standardized on the 13·5- to 27-Mc/s band. This band is specified since its corresponding scale calibrations occupy the longest arc on the dial. The dial can therefore be read with a high degree of discrimination on this band and the correct cursor setting most easily determined. Once the frequency scale has been standardized on the 13·5- to 27-Mc/s band, the cursor is correctly set to give the minimum mean error on the other three direct-multiple bands. It is also correctly set for the 1·5- to 13·5-Mc/s band.

When standardized in this way, the main tuning dial indication for frequencies above 13·5 Mc/s is accurate to at least 1%, and will generally be within 0·5%; for frequencies below 13·5 Mc/s, the average error does not exceed 3%.

2.4.3 THE INCREMENTAL FREQUENCY CONTROL

This control provides a convenient means of producing small, accurately known changes in carrier frequency. Since it is not connected directly to the r.f. oscillator, either mechanically or electrically, but operates by varying the d.c. voltage at the grid of the reactor valve, the control is completely free from any sort of backlash. This attribute, together with the directly calibrated scale, renders the control very suitable for bandwidth or similar measurements.

To use the control proceed as follows:—

(1) With the INC. FREQ. dial set to its centre zero position, tune the Signal Generator to the centre frequency of the equipment under test by means of the TUNE control.

(2) Rotate the INC. FREQ. control by the amount necessary to produce the required frequency shift or the required change in response depending on the method of measurement.

The scale of the INC. FREQ. dial is direct-reading on the 13·5- to 27-Mc/s band. For each of the other bands, a multiplying factor must be applied; the appropriate factor for each frequency band is engraved on the front panel adjacent to the RANGE switch marking. The multiplying factors are also given below in Table 1.

TABLE 1

RANGE switch setting (Mc/s)	*Total coverage of INC. FREQ. control (kc/s)*	*Multiply INC. FREQ. dial readings by*
1·5–13·5	±100	2
13·5–27	±50	1
27–54	±100	2
54–108	±200	4
108–220	±400	8

2.4.4 THE INTERPOLATING DIAL

The TUNE control knob is fitted with a small dial calibrated linearly from 0 to 100 over its total circumference and makes approximately 17 revolutions as the main dial is turned through its complete angle of rotation.

This dial may be used to subdivide linearly any portion of the frequency coverage on any band in order to tune accurately to a frequency above 13·5 Mc/s which does not coincide with a crystal check point. The method of using the dial for this purpose is described in the following instructions:—

(1) Set the INC. FREQ. control to zero.

(2) Set the RANGE switch to whichever of the four higher-frequency bands includes the required frequency.

(3) Tune the Signal Generator to the nearest crystal check point *below* the required frequency, identify the point with the aid of the CRYSTAL CHECK oscillator and note the interpolating dial reading.

(4) Tune the Signal Generator to the nearest crystal check point above the required frequency and note the change of reading of the interpolating dial. It is important that the *total* change is noted when the dial is turned through more than one revolution.

The relationship should be determined between the crystal check points which embrace the particular section of the frequency band over which incremental variations are to be made. Also, the relationship should be redetermined for each different section of the frequency band, since it varies, not only from band to band, but also for different sections of any one band.

(5) From the difference in frequency between the two crystal check points, and the total interpolating dial divisions traversed, calculate the frequency change per interpolating dial division.

(6) With the aid of the headphones, reset the main tuning dial to the crystal check point below the required frequency.

(7) Rotate the TUNE control so that the interpolating dial traverses the correct number of divisions to give the required frequency.

It is recommended that the required frequency should always be approached from the low-frequency side in order to eliminate the possibility of error due to backlash.

The following example illustrates the use of the interpolating dial to obtain an output from the instrument at an accurate frequency of 74·25 Mc/s.

Example: With the TUNE control set to the crystal check point at 72 Mc/s, the interpolating dial reading was 17. With the TUNE control set to the crystal

check point at 76 Mc/s the new reading on the auxiliary dial was 40. The total number of interpolating dial divisions traversed was 123, the dial having rotated through slightly more than one revolution for the frequency change of 4 Mc/s, i.e. 4,000 kc/s. In this case, a change of 1 division on the interpolating dial corresponded, between 72 *and* 76 *Mc/s*, to a nominal frequency change of

$$\frac{4000}{123} = 32{\cdot}5 \text{ kc/s}$$

Therefore, by starting from the original auxiliary dial setting at 72 Mc/s (72,000 kc/s) the required frequency of 74·25 Mc/s (74,250 kc/s) was obtained by rotating the auxiliary dial through

$$\frac{74{,}250-72{,}000}{32{\cdot}5} = \frac{2250}{32{\cdot}5} = 69 \text{ divisions.}$$

The interpolating dial can also, of course, be calibrated in kc/s per division for any portion of the 1·5- to 13·5-Mc/s band. Crystal check points cannot be used on this band, but the movement of the auxiliary dial for any frequency interval can be determined against the appropriate main dial calibration markings, and accurate interpolation between these marks carried out as previously described for the higher-frequency ranges.

2.5 SETTING UP FOR C.W., A.M. OR F.M.

The Signal Generator includes facilities which allow the following types of r.f. output to be obtained:—

(1) Continuous wave (see Section 2.5.1).

(2) Amplitude modulated (see Section 2.5.2), variable to 50% depth,
   (a) from the internal a.f. oscillator at 1,000 c/s,
   (b) from an external sine-wave source, within the range 50 c/s to 10 kc/s.

(3) Frequency modulated (see Section 2.5.3), variable to maximum frequency deviations ranging from 25 kc/s to 600 kc/s,
   (a) from the internal a.f. oscillator at 1,000 c/s,
   (b) from an external sine-wave source, within the range 50 c/s to 15 kc/s.

(4) Simultaneously frequency and amplitude modulated (see Section 2.5.4), the amplitude modulation being obtained from the internal a.f. oscillator, and the frequency modulation from an external source as (3) (b) above.

When setting up for amplitude or frequency modulation as described in Sections 2.5.2 and 2.5.3, it may be observed that, with the METER READS key held to either A.M. or F.M., as applies, the apparent modulation as measured on external apparatus is less than that indicated on the meter. This is quite in order; the meter indicates the modulation which will be obtained when the switch is returned to its central position and the meter reverts to its normal function of monitoring the r.f. level.

2.5.1 CONTINUOUS WAVE

(1) Set the MOD SELECTOR switch to C.W.

(2) Adjust the SET CARRIER control to bring the meter pointer to the SET R.F. mark.

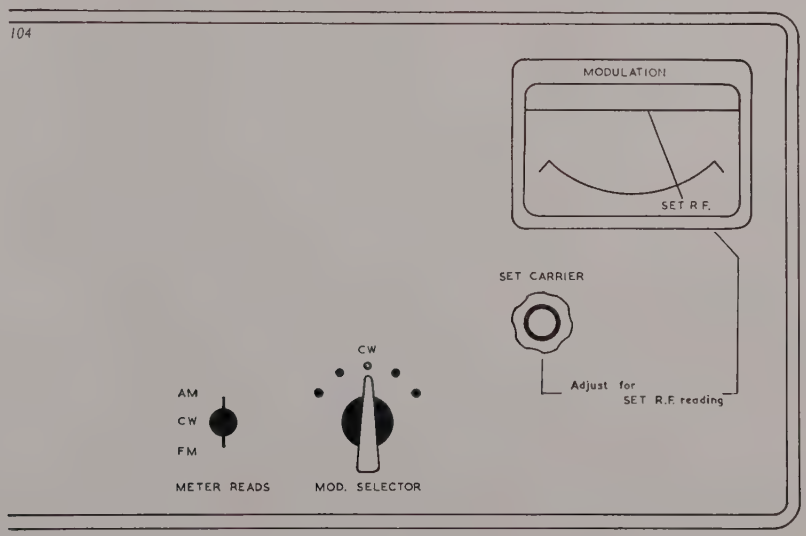


Fig. 2.3 C.W. Operation.

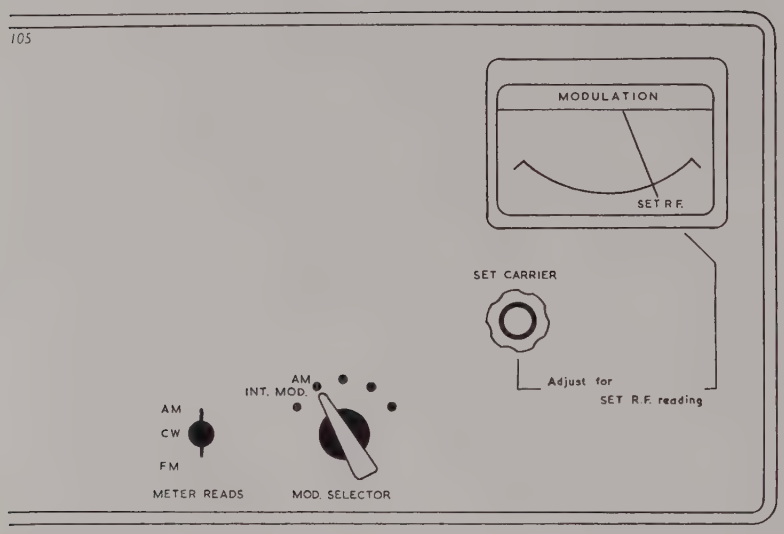


Fig. 2.4
Internal A.M. Operation.
(*a*) *Setting Carrier Level.*

2.5.2 AMPLITUDE MODULATION

(a) From the internal oscillator

(1) Set the MOD SELECTOR switch to INT MOD—A.M.

(2) Adjust the SET CARRIER control to bring the meter pointer to the SET R.F. mark.

(3) With the METER READS key switch held in the A.M. position, adjust the SET MOD control to the required modulation depth, as indicated on the top scale of the panel meter. Amplitude modulation is variable to a maximum depth of 50%.

(4) Release the METER READS key switch and, if necessary, repeat (2) above.

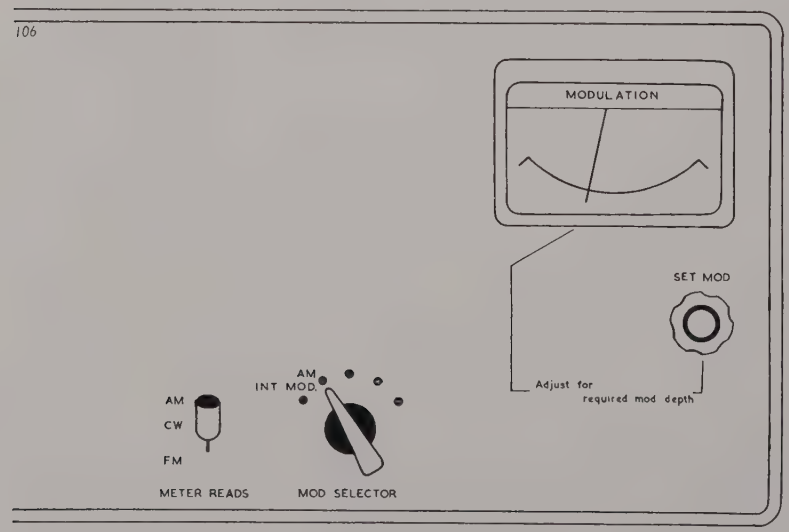
(b) From an external a.f. source

(1) Set the MOD SELECTOR switch to EXT MOD—A.M.

(2) Adjust the SET CARRIER control to bring the meter pointer to the SET R.F. mark.

(3) Connect the external modulation source to the EXT MOD and E terminals.

(4) With the METER READS key switch held in the A.M. position, adjust the SET MOD control to



(*b*) *Setting Modulation Depth.*

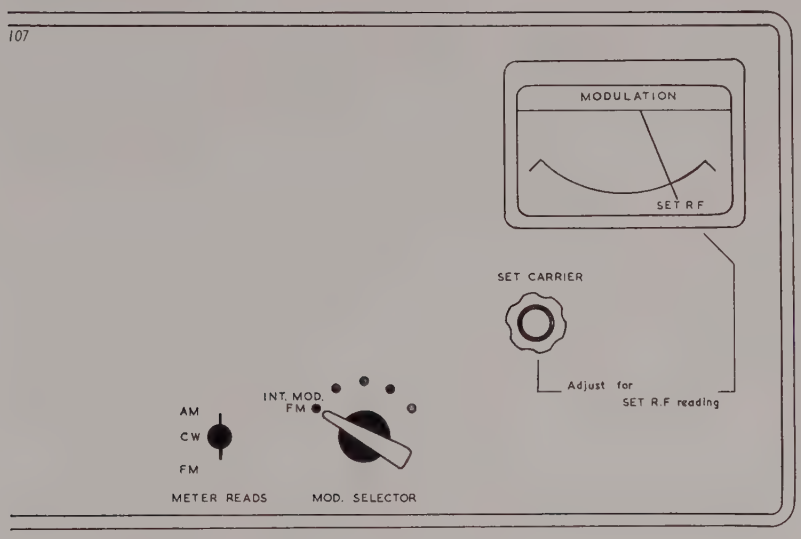


Fig. 2.5
Internal F.M. Operation.
(a) Setting Carrier Level.

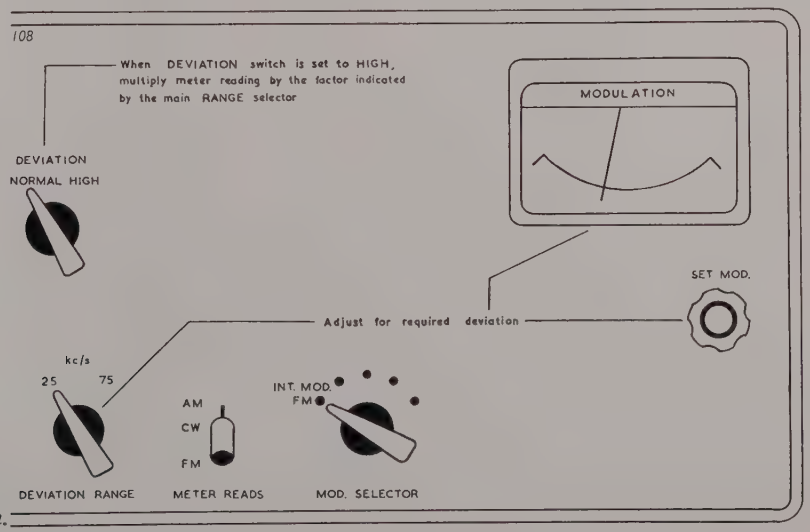
the required modulation depth, as indicated on the top scale of the panel meter. With the SET MOD control at maximum, an input of approximately 15 volts r.m.s. is required at the EXT MOD and E TERMINALS to produce 30% modulation depth within the modulation frequency range 50 c/s to 10 kc/s.

(5) Release the METER READS key switch and, if necessary, repeat (2) above.

2.5.3 FREQUENCY MODULATION

In addition to the MOD SELECTOR switch, there are three other controls concerned in setting up the carrier deviation when the output from the Signal Generator is to be frequency modulated. These controls are the continuously-variable SET MOD potentiometer, the DEVIATION RANGE switch, and the DEVIATION—NORMAL/HIGH switch. When the METER READS key switch is held to F.M., the panel meter indicates deviation. The meter has two deviation scales: one calibrated from 0 to 25 kc/s, and the other from 0 to 75 kc/s.

With the DEVIATION—NORMAL/HIGH switch set to NORMAL, the meter scale appropriate to the setting of the DEVIATION RANGE switch is used and the deviation is as indicated by the meter for all settings of the carrier-frequency range switch.



(b) Setting Modulation Depth.

TABLE 2

Carrier frequency RANGE switch setting (Mc/s)	*DEVIATION RANGE switch setting (kc/s)*	*DEVIATION—NORMAL/HIGH switch is set to HIGH*	
		Multiply meter reading by	*Maximum deviation obtainable (kc/s)*
1·5–13·5	25	2	50
	75	2	150
13·5–27	25	1	25
	75	1	75
27–54	25	2	50
	75	2	150
54–108	25	4	100
	75	4	300
108–220	25	8	200
	75	8	600

With the DEVIATION—NORMAL/HIGH switch set to HIGH, the deviation obtained on the 13·5- to 27-Mc/s band is the same as with the switch set to NORMAL. For all other carrier-frequency bands the deviation is increased and the meter readings—again taken on the scale appropriate to the settings of the DEVIATION RANGE switch—must be multiplied in accordance with Table 2 above.

The example given below shows the method of determining the meter reading for a required deviation which is greater than 75 kc/s and thus necessitates setting the DEVIATION—NORMAL/HIGH switch to HIGH.

Example: A deviation of 160 kc/s is required at a carrier frequency of 80 Mc/s. The carrier frequency lies within the 54- to 110-Mc/s band. The meter multiplying factor for this band is 4; therefore, for 160 kc/s deviation, the meter should be set (by means of the SET MOD control) to read

$$\frac{160}{4} = 40 \text{ kc/s}.$$

Do this on the bottom scale of the meter with the DEVIATION RANGE switch set to 75 kc/s.

(a) F.M. from the internal oscillator

(1) Set the MOD SELECTOR switch to INT MOD—F.M.

(2) Set the DEVIATION RANGE switch as required. If, at carrier frequencies less than 13·5 Mc/s, or greater than 27 Mc/s, more than 75 kc/s deviation is required, set the DEVIATION—NORMAL/HIGH switch to HIGH. (Deviations greater than 75 kc/s are not obtainable on the 13·5- to 27-Mc/s carrier-frequency band, the maximum deviations obtainable on the other carrier-frequency bands are given earlier in Table 2.)

(3) Adjust the SET CARRIER control to bring the meter pointer to the SET R.F. mark.

(4) With the METER READS key switch held to F.M., adjust the SET MOD control until the required deviation is indicated on the panel meter; read the meter on its middle scale when the DEVIATION range switch is set to 25 kc/s, and read on the lower scale when the switch is set to 75 kc/s. If the DEVIATION—NORMAL/HIGH switch is set to HIGH, the meter readings must be multiplied by the appropriate factor given in Table 2.

(5) Release the METER READS key switch and, if necessary, repeat (3) above.

(b) F.M. from an external source

(1) Set the MOD SELECTOR switch to EXT MOD—F.M.

(2) Set the DEVIATION RANGE switch as required. If at carrier frequencies less than 13·5 Mc/s, or greater than 27 Mc/s, more than 75 kc/s deviation is required, set the DEVIATION—NORMAL/HIGH switch to HIGH. (Deviations greater than 75 kc/s are not obtainable on the 13·5- to 27-Mc/s carrier-frequency band; the maximum deviations obtainable on the other carrier-frequency bands are given earlier in Table 2.)

(3) Adjust the SET CARRIER control to bring the meter pointer to the SET R.F. mark.

(4) Couple the external modulation source to the EXT MOD and E terminals.

(5) With the METER READS key switch held to F.M., adjust the SET MOD control until the required deviation is indicated on the panel meter; read the meter on its middle scale when the DEVIATION RANGE switch is set to 25 kc/s, and read on the lower scale when the switch is set to 75 kc/s. If the DEVIATION—NORMAL/HIGH switch is set to HIGH, the meter readings must be multiplied by the appropriate factor given in Table 2.

For any settings of the DEVIATION RANGE and DEVIATION—NORMAL/HIGH switches, and within the modulation frequency range 50 c/s to 15 kc/s, approximately 25 volts r.m.s. is required between the EXT MOD and E terminals for full deviation. With respect to 1 kc/s, the frequency characteristic of the modulation system is flat to within ± 1 dB from 50 c/s to 15 kc/s.

2.5.4 SIMULTANEOUS FREQUENCY AND AMPLITUDE MODULATION

(1) Set up the required depth of amplitude modulation as detailed in Section 2.5.2 (a).

(2) Leaving the MOD SELECTOR switch at INT MOD—A.M., and without altering the setting of the SET MOD control, set up the required deviation in a similar manner to that detailed in Section 2.5.3 (b); in this case, adjust the amount of deviation by variation of the audio input from the external modulation source.

2.6 R.F. OUTPUT ARRANGEMENTS

Five factors affect the output level from the Signal Generator; these factors are:

(a) The SET CARRIER control whose setting determines the input level to the attenuator cascade.

(b) The ' coarse ' or OUTPUT VOLTAGE attenuator.

(c) The ' fine ' or MULTIPLY BY attenuator.

(d) The TERMINATING UNIT which plugs on the end of the output cable from the fine attenuator.

(e) ATTENUATOR PAD Type TM 5552, which is an optional accessory designed for insertion between the output cable and TERMINATING UNIT when especially low output levels are required.

The SET CARRIER control is adjusted in conjunction with the panel meter; with the METER READS key switch in its central position, the panel meter forms part of a crystal voltmeter which monitors the input to the coarse attenuator. The panel meter has three main marks on its scale; these marks are minus 1 dB, SET R.F., and plus 1 dB, respectively. Normally, the SET CARRIER control should be adjusted to bring the meter pointer to the SET R.F. mark.

Four 20-dB steps give the coarse or OUTPUT VOLTAGE attenuator a total range of 80 dB; each setting of the attenuator control has markings in yellow (or red on earlier models) and in white. The yellow (or red) markings are in terms of decibels relative to 1 μV; the white markings are directly in units of voltage.

Ten 2-dB steps give the fine or MULTIPLY BY attenuator a total range of 20 dB; each setting of the attenuator control has markings in yellow (or red) and white, the yellow (or red) markings being in terms of decibels relative to 1 μV, and the white markings, multiplying factors for the white voltage markings on the coarse attenuator.

Both attenuators have a characteristic impedance of 75 ohms and, ' looking into ' the coaxial socket at the end of the output cable, the instrument appears as a generator with a source impedance of 75 ohms.

The TERMINATING UNIT is, essentially, a 6-dB attenuator pad; ' looking into ' its input socket, the TERMINATING UNIT presents an impedance of 75 ohms, while the two outlets present impedances of 52 and 75 ohms respectively.

The ATTENUATOR PAD has a characteristic impedance of 75 ohms and provides an optional, additional, 20-dB attenuation of the output signal.

It should be noted particularly that the r.f. output controls on the Signal Generator are calibrated in terms of source e.m.f. or open-circuit output voltage. The significance of quoting the output of a signal generator in this way will be apparent when it is remembered that one of the primary functions of a signal generator is to simulate a received signal as it would come from an aerial.

To take a simple case—that in which a 75-ohm receiver is fed from a 75-ohm dipole, the e.m.f. induced in the aerial is shared between its inherent 75-ohm radiation resistance and the matched 75-ohm receiver input. Clearly, when the same receiver is fed from a signal generator, the corresponding signal strength is given by the source e.m.f. of the signal generator, and not by the on-load p.d. at the receiver terminals.

2.6.1 OUTPUTS FROM 1 μV TO 100 mV AT 52 AND 75 OHMS

It is intended that the Signal Generator should normally be used with the SET CARRIER control adjusted to bring the meter pointer to the SET R.F. mark; with the TERMINATING UNIT coupled directly to the output cable; and without the ATTENUATOR PAD Type TM 5552.

Used in this way, the Signal Generator should be regarded as a source of zero impedance in series with a resistance of either 75 ohms or 52 ohms, the open-circuit output level, or source e.m.f., being variable in 2-dB steps from 1 μV to 100 mV and being given:

(a) *directly in terms of decibels relative to* 1μV, by the sum of the ' yellow ' (or red) settings of the OUTPUT VOLTAGE and MULTIPLY BY attenuators;

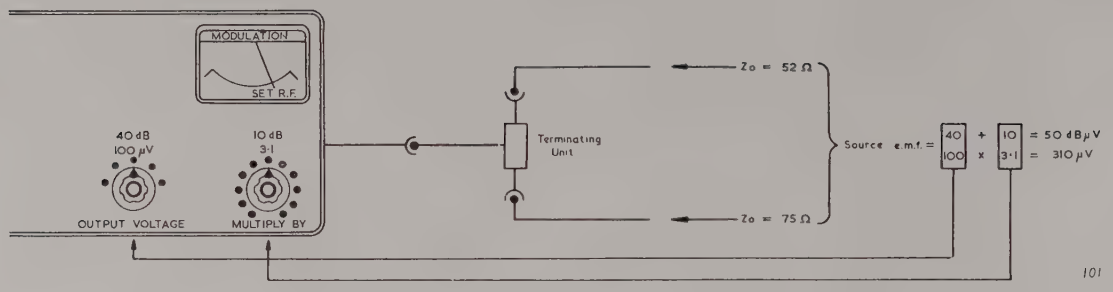


Fig. 2.6 Outputs via Terminating Unit.

(b) *directly in voltage*, by the product of the ' white ' settings of the OUTPUT VOLTAGE and MULTIPLY BY attenuators.

The plus 1-dB and minus 1-dB marks on the panel meter allow interpolation between the 2-dB steps of the MULTIPLY BY attenuator. Setting the meter pointer to either the plus 1-dB or minus 1-dB mark increases or decreases the input to the attenuator cascade by 1 decibel. Thus, using the SET CARRIER control and panel meter in conjunction with the OUTPUT VOLTAGE and MULTIPLY BY attenuators, the output level from the Signal Generator can be varied in 1-dB steps over the range 0 to +100 dB relative to 1 μV.

It should be noted that the ' white ' voltage indication given by the attenuator controls is not directly applicable when the meter is set to other than the SET R.F. mark; with the meter at minus 1 dB, the source e.m.f. at the TERMINATING UNIT outlets is 0·89 of the indicated voltage; with the meter at plus 1 dB, the source e.m.f. is 1·12 of the indicated voltage.

2.6.2 OUTPUTS FROM 2 μV TO 200 mV AT 75 OHMS ONLY

With the TERMINATING UNIT detached and with the meter at the SET R.F. mark, the output level obtained directly from the plug at the end of the r.f. output cable is variable in the range 2 μV to 200 mV and is derived via a source impedance of 75 ohms.

Under these conditions, the open-circuit level, or source e.m.f., in terms of decibels relative to 1 μV is obtained by adding 6 dB to the sum of the meter reading and the ' yellow ' (or red) indications of the OUTPUT VOLTAGE and MULTIPLY BY attenuators; the source e.m.f. is given directly in voltage by doubling the product of the ' white ' indications of the OUTPUT VOLTAGE and MULTIPLY BY attenuators.

2.6.3 OUTPUTS FROM 0.1 μV TO 10 mV AT 52 AND 75 OHMS

With the TERMINATING UNIT coupled to the r.f. output cable via the optional 20-dB ATTENUATOR PAD and with the meter at the SET R.F. mark, the output level from the TERMINATING UNIT is variable in the range 0·1 μV (nominal) to 10 mV.

In this case, the source e.m.f. in terms of decibels relative to 1 μV is obtained by subtracting 20 dB from the sum of the meter reading and the ' yellow ' (or red) indications of the OUTPUT VOLTAGE and MULTIPLY BY attenuators; the source e.m.f. is given directly in voltage by dividing the product of the ' white ' indications of the OUTPUT VOLTAGE and MULTIPLY BY attenuators by 10.

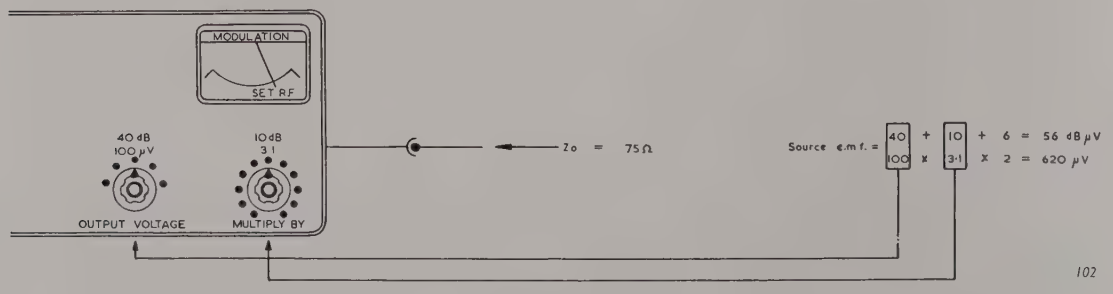


Fig. 2.7 Output Direct from Output Lead.

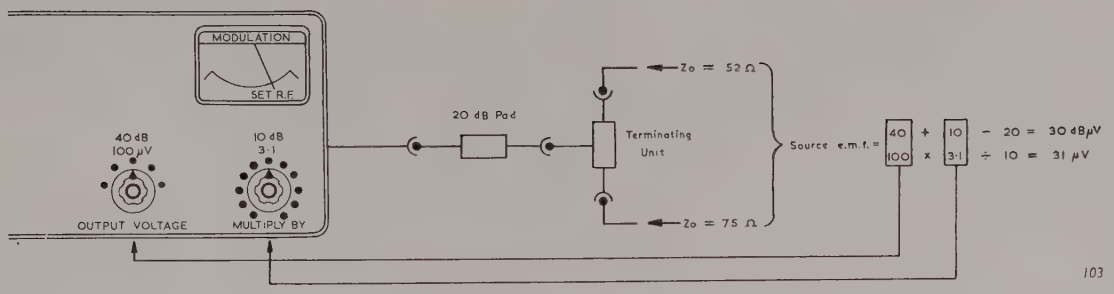


Fig. 2.8 *Outputs via* 20-*dB Pad and Terminating Unit.*

2.6.4 OUTPUT IN TERMS OF VOLTAGE DEVELOPED ACROSS AN EXTERNAL LOAD

For some particular applications, it may be desired to work not in terms of source e.m.f. as indicated by the meter and attenuator controls, but in terms of actual voltage developed across the external load. This on-load, or terminal voltage, is given by the expression

$$V_L = E \times \frac{Z_L}{Z_0 + Z_L} \qquad \text{.....(1)}$$

where V_L = actual voltage developed across the external load.

E = the source e.m.f. of the Signal Generator.

Z_L = the impedance of the external load.

Z_0 = the source impedance of the Signal Generator; (with the TERMINATING UNIT in use, $Z_0 = 75$ or $52\,\Omega$; with the TERMINATING UNIT removed, $Z_0 = 75\,\Omega$).

The expression is based on the assumption that the external load impedance Z_L is essentially resistive. Where Z_L is not essentially resistive, it may be necessary for the user to revise the expression to take account of the reactive component of the load.

A series of multiplying factors, which can be used to convert from source e.m.f. to actual voltage developed across an external resistive load, and which have been derived with the aid of the above expression, are given in Table 3 for a selection of typical load values.

2.6.5 MATCHING TO EXTERNAL LOADS OTHER THAN 52 OR 75 OHMS

The TERMINATING UNIT supplied with the Signal Generator allows r.f. outputs to be obtained from a source impedance of either 52 or 75 ohms.

If the equipment under test has an input impedance of other than 52 or 75 ohms, and if it is required to present the equipment with a signal derived from a matched source, then it is necessary to modify the output arrangements of the Signal Generator. The simple modifications required are described in sub-sections (a) and (b) which follow.

In these sub-sections it is assumed that the TERMINATING UNIT is in circuit, and that the 20-dB ATTENUATOR PAD is out of circuit.

(a) External load less than that of the TERMINATING UNIT outlet in use.

The impedance presented to the load can be made equal to the load impedance by shunting the TERMINATING UNIT outlet with a single resistor, R_p, where

$$R_p = \frac{Z_0 \times Z_L}{Z_0 - Z_L} \qquad \text{.....(2)}$$

TABLE 3

External load impedance in ohms	*Approximate multiplying factor to convert from source e.m.f. to actual voltage developed across an external resistive load*	
	Z_0 75Ω	Z_0 52Ω
10	0·12	0·16
20	0·21	0·28
30	0·29	0·36
40	0·35	0·43
50	0·4	0·49
52	0·41	0·5
60	0·44	0·53
70	0·48	0·57
75	0·5	0·59
80	0·51	0·61
100	0·57	0·65
150	0·67	0·74
200	0·73	0·79
300	0·8	0·85
600	0·89	0·92

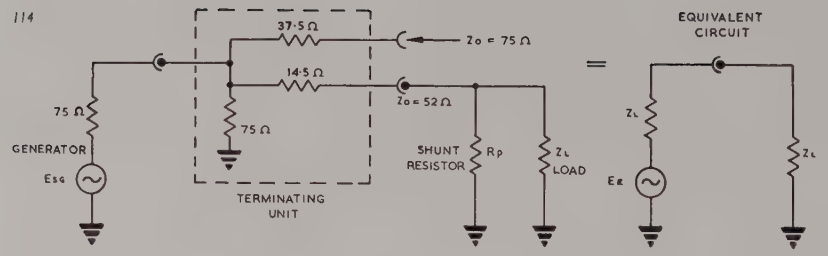


Fig. 2.9
Matching to Low-Impedance Loads.

and where Z_0 = the source impedance of the Signal Generator at the TERMINATING UNIT outlet in use;

Z_L = the impedance of the external load.

Under these conditions, the relationship between E_{SG}, the e.m.f. indicated by the attenuator controls on the Signal Generator, and E_E, the effective source e.m.f. presented to the external load, is given by the expression

$$E_{SG} = E_E \times \frac{R_p + Z_0}{R_p} \quad \text{.....(3)}$$

Example: It is required to provide a signal of 25 μV effective source e.m.f. at a source impedance of 20 ohms.

Since the new source impedance is to be 20 ohms, the output is taken from the 52-ohm outlet on the TERMINATING UNIT, the 52-ohm outlet being chosen in preference to the 75-ohm outlet to obtain the minimum reduction from E_{SG} to E_E.

From expression (2), the value of R_p to be connected in parallel with the 52-ohm outlet of the TERMINATING UNIT is

$$\frac{52 \times 20}{52 - 20} = 32{\cdot}5\,\Omega.$$

From expression (3), the attenuator controls on the Signal Generator should be set to indicate

$$25 \times \frac{32{\cdot}5 + 52}{32{\cdot}5} = 65\ \mu V.$$

The attenuators cannot be set to indicate exactly 65 μV and they should therefore be set to 63 μV—the setting nearest to the required value for E_{SG}. 63 μV is approximately −0·3 dB relative to 65 μV and, if desired, the user may obtain an E_{SG} nearer to 65 μV by adjustment of the SET CARRIER control to bring the meter pointer to an estimated +0·3 dB.

As a result of shunting the output of the TERMINATING UNIT with 32·5 ohms and setting the attenuator controls in the manner described, the equipment under test is fed from a source whose effective output impedance is 20 ohms and whose effective source e.m.f. is 25 μV; the actual voltage developed across the input impedance of the equipment under test is, of course, 12·5 μV.

(b) External load greater than that of the TERMINATING UNIT outlet in use.

The impedance presented to the load can be made equal to the load impedance by connecting a single resistor, R_S, in series with the Signal Generator output. The value of R_S is given by the expression

$$R_S = Z_L - Z_0 \quad \text{.....(4)}$$

where Z_L = the impedance of the external load.

Z_0 = the source impedance of the Signal Generator at the TERMINATING UNIT outlet in use.

Under these conditions, the effective source e.m.f. (E_E) of the Signal Generator and series resistor combined, equals the source e.m.f. (E_{SG}) of the Signal Generator alone,

$$\text{i.e. } E_{SG} = E_E \quad \text{.....(5)}$$

Example: It is required to provide a signal of 10 μV effective source e.m.f. at a source impedance of 300 ohms.

Since the new output impedance is greater than

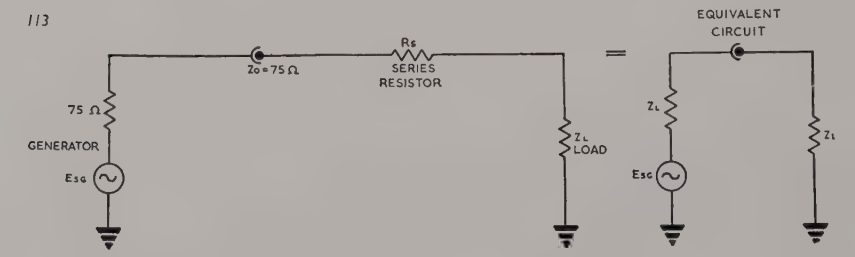


Fig. 2.10
Matching to High-Impedance Loads.

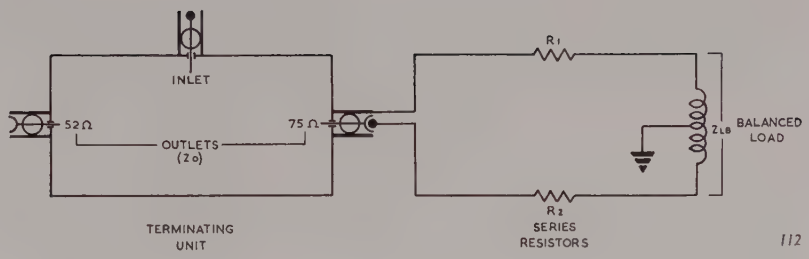


Fig. 2.11 Matching to Balanced Loads.

either 52 or 75 ohms, there is no advantage to be gained by using one of the TERMINATING UNIT outlets in preference to the other; in this example it is assumed that the 75-ohm outlet is used.

From expression (4) the value of R_S to be connected in series with the 'live' connection between the Signal Generator and the equipment under test, is

$$300-75 = 225\,\Omega$$

From expression (5), the attenuators on the Signal Generator should be set to indicate

$$10\ \mu V.$$

In this way, the equipment under test is fed from a source whose effective impedance is 300 ohms and whose effective source e.m.f. is 10 μV; the actual voltage developed across the input impedance of the equipment under test is, of course, 5 μV.

2.6.6 MATCHING TO BALANCED LOADS

The preceding Sections dealing with r.f. output arrangements are based on the supposition that the equipment being fed from the Signal Generator has an unbalanced input circuit.

With certain types of equipment, the input circuit is in the form of a balanced winding; such equipment can be fed from the unbalanced output of the Signal Generator by interposing two loading resistors between the TERMINATING UNIT outlet and the ends of the balanced input winding.

One resistor, R_1, is connected in series between the earth connection of the TERMINATING UNIT outlet in use and one side of the balanced winding; the other resistor, R_2, is connected in series between the 'live' connection of the TERMINATING UNIT outlet in use and the other side of the balanced winding.

Values for R_1 and R_2 may be computed from the following expressions:

$$R_1 = \frac{Z_{LB}}{2} \qquad \text{.....(6)}$$

$$R_2 = \frac{Z_{LB}}{2} - Z_0 \qquad \text{.....(7)}$$

where Z_{LB} = the total line-to-line impedance of the balanced winding.

Z_0 = the source impedance of the Signal Generator at the TERMINATING UNIT outlet in use.

With the equipment under test and the TERMINATING UNIT of the Signal Generator interconnected via R_1 and R_2 as described above, the source e.m.f. (E_{SG}) indicated by the Signal Generator controls is equal to the effective line-to-line source e.m.f. (E_E) seen by the equipment under test.

Example: It is required to match the 75-ohm outlet to a balanced winding whose total line-to-line impedance is 200 ohms.

From expression (6), the value of R_1 is

$$\frac{200}{2} = 100\,\Omega.$$

From expression (7), the value of R_2 is

$$\frac{200}{2} - 75 = 25\,\Omega.$$

R_1 is connected in series with the earth connection of the TERMINATING UNIT and one side of the balanced winding; R_2 is connected in series with the 'live' connection between the TERMINATING UNIT and the other side of the balanced winding.

2.7 SYNCHRONIZING SIGNAL

A 1,000-c/s sine wave signal, derived from the internal a.f. oscillator, is available between the SYNC and E terminals of the instrument when the MOD SELECTOR switch is set at either of the INT MOD positions. This signal has an open-circuit level of the order of 100 volts and is derived via a source impedance of approximately 250 kΩ.

When an output from the equipment under test is being viewed on a cathode-ray oscilloscope, it will often be found convenient to lock the c.r.o. time base directly with the SYNC signal rather than with the actual signal being viewed.

The SYNC output can, of course, also be used when an audio frequency signal is required for the equipment under test.

3 Operational Summary

When the user is familiar with the principles and techniques of operation detailed in Section 2 of this handbook, the following abridged operating instructions may be found convenient.

Check correctness of mains transformer tappings before use.

STANDARDIZING THE FREQUENCY SCALE

Switch mains ON and set RANGE MC/S switch to 13·5–27; with MOD SELECTOR switch set to other than INT MOD—F.M. or EXT MOD—F.M., and using headphones plugged into CRYSTAL CHECK socket, tune main dial to crystal check point near centre of band. Bring movable cursor in line with dial calibration corresponding to crystal check point. Check accuracy of frequency indication above and below point to which cursor was originally set, equalize errors over band by readjusting cursor.

For further details, refer to Section 2.4.2.

TUNING

Set RANGE MC/S switch to band required; rotate TUNE control until cursor indicates required frequency. For higher frequency-accuracy, compute relationship of frequency change to change in auxiliary dial setting between crystal check points or scale markings embracing required frequency. Starting from selected point below required frequency, rotate TUNE control so that incremental dial traverses calculated number of divisions.

For further details, refer to Sections 2.4.1 *and* 2.4.4.

INCREMENTAL FREQUENCY ADJUSTMENT

Make small carrier changes by means of INC. FREQ. control, using multiplying factors as shown on front panel.

For further details, refer to Section 2.4.3.

C.W. OPERATION

With MOD SELECTOR switch set to C.W., adjust SET CARRIER to bring meter pointer to SET R.F.; adjust step attenuators to obtain required output level.

For further details, refer to Section 2.5.1.

AMPLITUDE MODULATION

Internal:

With MOD SELECTOR switch at INT MOD—A.M., adjust SET CARRIER to bring meter pointer to SET R.F. With METER READS switch at A.M., adjust SET MOD to bring meter pointer to required modulation depth. Release METER READS switch and, if necessary, readjust SET CARRIER; adjust step attenuators to obtain required output level.

External:

As for internal, except that MOD SELECTOR switch is set to EXT MOD—A.M., and external signal injected between EXT MOD and E terminals. Approximately 15 volts r.m.s. (50 c/s to 10 kc/s) is required to produce 30% modulation.

For further details, refer to Section 2.5.2.

FREQUENCY MODULATION

Internal:

With MOD SELECTOR switch at INT MOD—F.M., adjust SET CARRIER to bring meter pointer to SET R.F. With DEVIATION—NORMAL/HIGH switch at NORMAL, and METER READS switch at F.M., adjust SET MOD to bring meter pointer to required deviation on meter scale appropriate to DEVIATION RANGE switch setting. (For deviations greater than 75 kc/s, set DEVIATION—NORMAL/HIGH switch to HIGH and multiply meter readings by factor given in Table 2, Section 2.5.3.) Release METER READS switch and, if necessary, readjust SET CARRIER; adjust step attenuators to obtain required output level.

External:

As for internal, except that MOD SELECTOR switch is set to EXT MOD—F.M. and external signal injected between EXT MOD and E terminals. Approximately 25 volts r.m.s. (50 c/s to 15 kc/s) is required to produce full deviation.

For further details, refer to Section 2.5.3.

SIMULTANEOUS FREQUENCY AND AMPLITUDE MODULATION

Set up as for AMPLITUDE MODULATION, INTERNAL. Then, with MOD SELECTOR switch still set at INT MOD—A.M., apply external signal (50 c/s to 15 kc/s) between EXT MOD and E terminals. Adjust level of external signal to produce required deviation; do not readjust SET MOD control.

For further details, refer to Section 2.5.4.

4 Technical Description

4.1 R.F. CIRCUITS

The r.f. oscillator itself (V3) is variable only over a fundamental frequency range of 4·5 to 9·16 Mc/s; the four higher frequency bands are obtained from a chain of four ganged multipliers (V6, V8, V10, and V12) of ×3, ×2, ×2, and ×2 respectively. The setting of the frequency switch determines which of the multipliers acts as the output stage. Output over the 1·5- to 13·5-Mc/s band is obtained by applying the 27- to 54-Mc/s output of the second multiplier to a single valve circuit (V7a) which combines the functions of mixer and 30-Mc/s oscillator. The variable-frequency output from the second multiplier is thus heterodyned with a fixed 30-Mc/s signal, and the output from the oscillator/mixer stage contains a difference-frequency component which is utilized—after filtering and amplification (by V7b)—to provide outputs between 1·5 and 13·5 Mc/s.

The main tuning dial has five scales, all direct-reading in output frequency. To facilitate tuning, a slow-motion worm-and-wheel drive is incorporated; this control is fitted with a dial marked linearly from 0 to 100 to assist the operator in subdividing the frequency scales of the main tuning dial. In addition, there is a directly-calibrated separate incremental frequency control with a total cover of 50, 100, 200, or 400 kc/s, depending on the band in use.

A carrier on/off switch (S7) is included to enable the r.f. signal to be interrupted without affecting the output circuits of the generator. This switch interrupts the h.t. supply to the r.f. oscillator valve and also the supply to the screens of the multiplier valves for the band in use.

For all the r.f. bands, the output is taken via two resistive 75-ohm ladder-network attenuators in cascade. The first attenuator has a range of 80 dB and is variable in 20-dB steps; the second has a

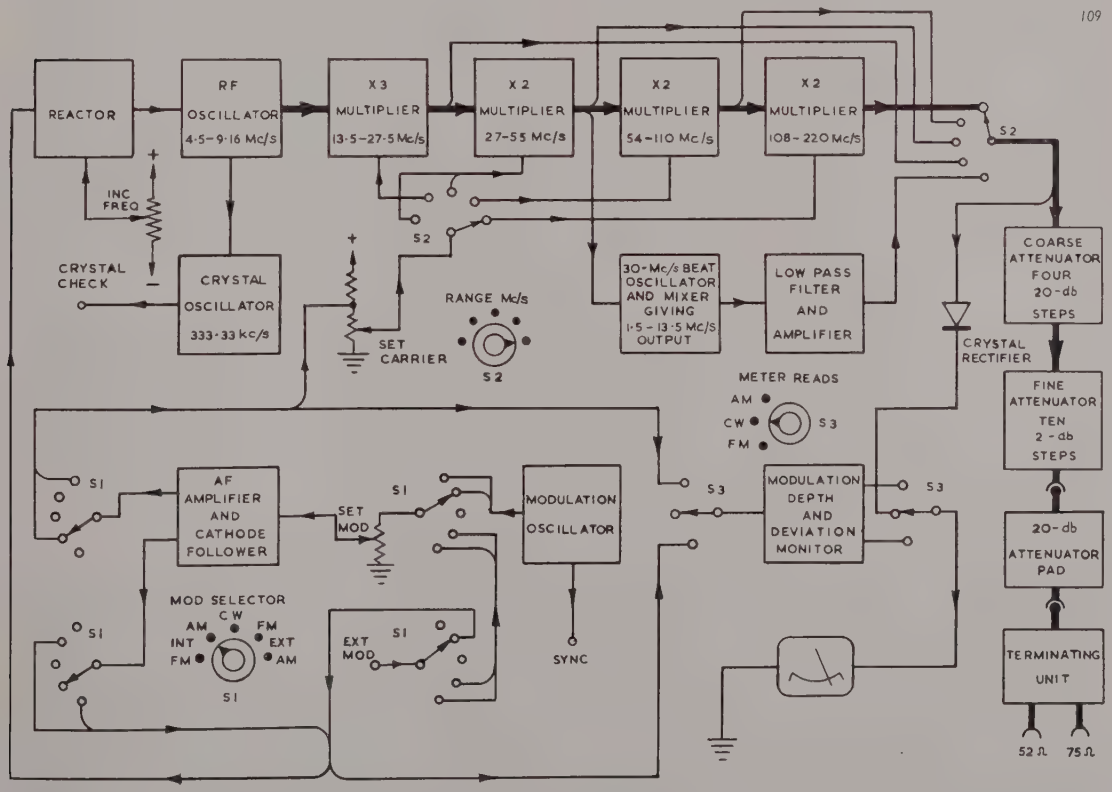


Fig. 3.1 Block Schematic Diagram.

range of 20 dB in 2-dB steps. The input to the cascade is adjustable by means of the SET CARRIER control (R44), and is monitored by the MODULATION meter M1. The meter scale has a SET R.F. mark, and respectively above and below this mark, plus and minus 1-dB marks to allow interpolation between the 2-dB steps of the attenuator. The output from the second attenuator is applied to a coaxial cable which is permanently attached to the instrument; the direct open-circuit output obtainable from this cable is at a source impedance of 75 ohms and is variable between 2 μV and 200 mV. By using the plug-on Terminating Unit supplied, outputs 6 dB down on this range are obtainable at source impedances of both 75 and 52 ohms. With the optional Attenuator Pad interposed between the output cable and the Terminating Unit, outputs down to 0·1 μV are obtainable.

To provide for incremental carrier shift and for frequency modulation, a reactor valve (V2) is included in the tuned circuit of the r.f. oscillator. Movement of the INC. FREQ. control (R112) varies the d.c. bias applied to the grid of V2, causing a change in its mutual conductance and thus a change in the r.f. oscillator frequency. Both the d.c. shift voltage and the a.f. modulating signal are applied to the grid of the reactor valve via a tracking potentiometer (R7); this is ganged to the main tuning capacitor so that the deviation or carrier shift is kept constant as the Signal Generator is tuned over any one band.

The built-in crystal calibrator—the crystal unit of which has a fundamental frequency of 333·3 kc/s—is coupled to the variable-frequency r.f. oscillator and provides 14 checking points on each of the four upper frequency bands covered by the Signal Generator. The h.t. supply to the calibrator is automatically switched on by the insertion of a telephone plug into the CRYSTAL CHECK jack on the front panel; the heterodyne beats at the checking points may then be heard in the headphones or via the receiver under test. The cursor of the tuning dial is adjustable so that it may be set to correspond exactly with the nearest crystal checking point.

4.2 MODULATION SYSTEMS

Amplitude and frequency modulation may be applied, from either an internal a.f. source or external sources. The internal source is a 1,000-c/s oscillator (V1).

For frequency modulation, the a.f. signal passes through a cathode follower (V5) and is normally fed to the reactor, not only through the variable tracking potentiometer, but also via a switched potentiometer system ganged to the RANGE switch. By this means, the ratio of a.f. input voltage to f.m. deviation is maintained constant at all frequencies on every band and is independent of the setting of either the RANGE switch or tuning control. The normal deviation ranges on all carrier bands are 0 to 25 kc/s and 0 to 75 kc/s, but switching (S5, the DEVIATION—NORMAL/HIGH switch) is provided so that the switched potentiometer system can be bypassed, thus enabling the deviation to be increased proportionally with frequency multiplication, being 75 × 8, or 600 kc/s on the highest r.f. band.

Amplitude modulation, to a depth continuously variable up to 50%, is applied to the highest-frequency harmonic multiplier which is operating for the particular r.f. output band in use; this method helps to reduce the spurious frequency modulation often encountered when modulating an r.f. oscillator directly.

Simultaneous amplitude and frequency modulation—of use, for example, when investigating the performance of limiter stages in f.m. receivers—is obtained by setting up the instrument for internal a.m. and then applying f.m. from an external source.

4.3 MONITORING ARRANGEMENTS

A moving-coil microammeter on the front panel, used in conjunction with a crystal rectifier, continuously monitors the r.f. input to the attenuators when a spring-loaded key-switch is in the ' normal ' position; the two alternative key positions are for reading f.m. deviation and a.m. depth respectively, the former by the measurement of the a.f. modulating voltage injected into the reactor valve and the latter by similarly checking the a.f. voltage being applied via the h.t. feed circuit to the screen of whichever multiplier is operating as modulator stage. The design of the modulation monitoring circuits is such that, with the Signal Generator set up for simultaneous a.m. and f.m., both percentage depth and deviation can be read independently.

4.4 POWER UNIT

A full-wave rectifier provides the positive d.c. h.t. supply; in the case of the reactor and r.f. oscillator valves, the h.t. is stabilized by means of a gas-filled stabilizer tube. A negative supply for the reactor-valve bias is drawn from a voltage-doubling circuit employing a double-diode valve and a gas-filled stabilizer. The primary of the transformer is tapped to allow for operation from 100 to 150 volts or 200 to 250 volts, and adequate r.f. filtering is introduced into the a.c. input circuit.

5 Maintenance

5.1 GENERAL

Section 4, TECHNICAL DESCRIPTION, of this handbook deals with the internal circuits of the Signal Generator and it is strongly recommended that the user should familiarize himself with the principles described there before commencing the adjustment or replacement of component parts of the instrument.

The complete Circuit Diagram shows all the electrical components contained in the instrument together with their values. The full description of these components is given in the Spares Ordering Schedule; the Schedule also lists certain selected mechanical components.

The physical location of the electrical components is shown on the Component Layout Illustrations.

5.2 REMOVAL OF CASE

To remove the Signal Generator case:—

(1) Remove the screw securing the small plate in the left-hand side pocket; the mains lead is cleated to the case by means of this plate.

(2) Extract the eight screws from around the edge of the front panel.

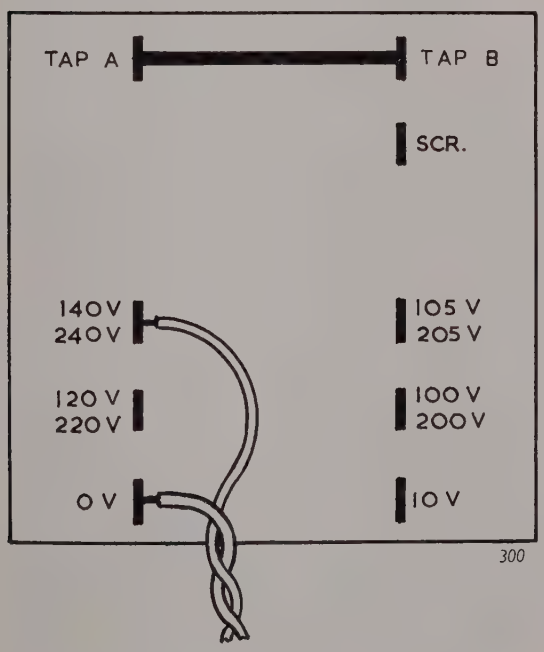
(3) Pull the instrument clear of its case and disconnect the six-way interconnecting cable from the power unit chassis.

(4) Detach the screw, from the inside of the case, which holds the cleating plate for the r.f. output cable to the right-hand side pocket.

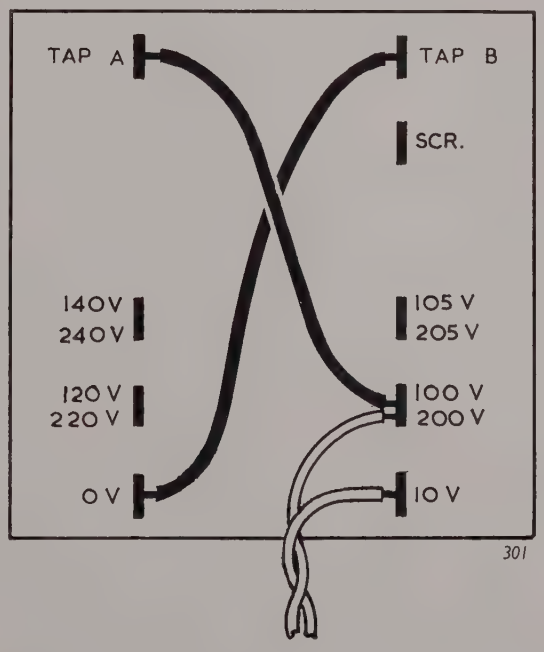
5.3 MAINS INPUT ARRANGEMENTS

The instrument is fitted with a mains transformer which has a double-wound primary; each primary section is tapped and the two sections can be connected in series-parallel for 100- to 150-volt operation or in series for 200- to 250-volt operation.

The 100- to 150-volt or the 200- to 250-volt range is selected by links on the coil of the transformer. Selection of intermediate voltages within either range is made by means of fly leads on the transformer tags. These tags are common to both



(*a*) 240-*volt Connections.*



(*b*) 110-*volt Connections.*

Fig. 5.1 *Mains Transformer Tappings.*

ranges and are, therefore, annotated with two voltages; the applicable voltage depends on the position of the range links.

One fly lead must always be connected to either the ' 0 ' or the ' 10 ' tag; the other is connected to the tag whose voltage, added to 0 or 10 as appropriate, equals the mains supply voltage. Do not connect the fly leads to the tags marked TAP A or TAP B.

In order to examine the connections to the transformer and, if necessary, make adjustments, the instrument must be removed from its case in the manner described in Section 5.2. With the instrument out of its case, the transformer (Reference T4 on the Circuit Diagram, and on Component Layout Illustration, Fig. 6.8) is immediately accessible.

For Supply Voltages within the range 200 to 250 volts, the tags on the transformer *must* be linked in the following manner:—

' TAP A ' to ' TAP B '

For Supply Voltages within the range 100 to 150 volts, the tags on the mains transformer *must* be linked in the following manner:—

' 0 ' to ' TAP B '
' 100/200 ' to ' TAP A '

On earlier models the mains transformer is of slightly different mechanical construction. It is identified by having a mains-tapping plate fixed to its rear edge. Attached to this panel is a pierced reference plate which is reversible and marked with a selection of voltages. On one side of the plate, the voltages are applicable to the 100- to 150-volt range; on the other side, to the 200- to 250-volt range.

The two sections of the primary are connected together by means of links soldered between tags, numbered 1-2-3-4, on an insulated strip at the front of the transformer.

For 200- to 250-volt operation, link tag 2 to tag 3.

For 100- to 150-volt operation, link tag 1 to tag 2 and tag 3 to tag 4.

5.4 ACCESS TO ENCLOSED SUB-ASSEMBLIES

General tests or some peculiarity in the performance of the Signal Generator may suggest the desirability of inspecting the interior of one of the enclosed sub-assemblies which form part of the instrument. Any of these sub-assemblies can be dismantled by the appropriate procedure as detailed in the following sections.

5.4.1 R.F. UNIT

To remove the screening cover from the r.f. unit:—

(1) With the instrument removed from its case, lay it on its face.

(2) Extract the two screws which secure the screening cover of the r.f. unit.

(3) Grip the sides of the screening cover and draw it off; the cover is held by earthing contact springs and will consequently offer some resistance to removal.

5.4.2 ' MULTIPLY BY ' ATTENUATOR

A view of the MULTIPLY BY (fine) attenuator with the screening cover removed is shown in the Component Layout Illustration, Fig. 6.7. To dismantle the attenuator:—

(1) Remove the attenuator screening cover after extracting the single securing screw.

(2) Remove the front-panel control knob after slackening the two grub screws which secure it to its associated spindle.

(3) Detach the main body of the attenuator from the front panel by extracting five screws; three of these screws are visible on removal of the control knob as in (2) above; the two remaining screws are located immediately above the 8-dB and 12-dB panel markings respectively.

With the attenuator thus detached, it remains coupled to the body of the instrument by two coaxial leads; these leads are normally long enough to permit inspection and, if necessary, replacement of the attenuator resistors without completely disconnecting the attenuator.

Reassemble the attenuator in the reverse order to that detailed above.

5.4.3 ' OUTPUT VOLTAGE ' ATTENUATOR AND MONITOR CRYSTAL X2

In addition to the actual attenuator components, the r.f. monitor crystal, X2, and its associated filter components are mounted in the OUTPUT VOLTAGE attenuator casing. When dismantling the attenuator, the user should refer to Component Layout Illustration, Fig. 6.7. Access to the crystal, X2, resistors R71 and R72, and capacitors C88, C89, and C90 can be obtained by removing the cover of the attenuator in the following manner:

(1) Disconnect R70 from the small insulated spigot projecting through the cover of the attenuator.

(2) Remove the central securing screw and lift the screening cover clear of the attenuator body.

To obtain access to the attenuator resistors, R73 to R82, detach the attenuator from the front panel of the Signal Generator in the following manner:—

(3) Remove the control knob by slackening the two grub screws securing it to its spindle.

(4) Extract the five fixing screws securing the attenuator to the front panel; three of these screws are immediately visible on removing the control knob as in (3) above; the two remaining screws are located immediately above and to the right of the coarse-attenuator panel markings.

With the attenuator detached as in (4) above, it remains coupled to the body of the instrument by two coaxial cables. These cables are, however, long enough to permit inspection and, if necessary, replacement of the attenuator-resistors without completely disconnecting the attenuator.

Reassemble the attenuator in the reverse order to that detailed above.

5.4.4 MAINS INPUT FILTER UNIT

To gain access to the components comprising the mains input filter:—

(1) Remove the nut and screw which secure, at the open end, the two halves of the mains filter unit screening cover.

(2) Separate the push-fit screening channel from the fixed half of the screening cover.

Reassemble the screening cover in the reverse order to that detailed above.

5.4.5. POWER UNIT

To remove the power unit from the instrument case:—

(1) Remove, from the underside of the instrument case, the five screws which engage with nuts along the front and left-hand flanges of the power unit chassis.

(2) Holding the power unit with one hand, remove the remaining two screws which engage with the tapped bushes on the right-hand flange of the power unit.

Replace the power unit in the reverse order to that detailed above.

5.5 WORKING VOLTAGES

The voltages given in this section for guidance when servicing the instrument were obtained from measurements on a representative Signal Generator Type TF 995A/2M; the voltmeter used had a resistance of 20,000 ohms per volt.

Mains Transformer, h.t. secondary	250–0–250 V a.c.
Mains Transformer, l.t. (rectifier)	5 V a.c.
Mains Transformer, l.t. (main)	6·3 V a.c.
Positive H.T.:—	
Rectified (V11, pin 8)	300 V d.c.
Smoothed, HT1 (across C62)	230 V d.c.
Stabilized, HT3 (V9, pin 5)	150 V d.c.
Negative H.T. (junction of R117 and R118)	85 V d.c.

Valve electrode voltages are given in Table 4.

All voltages listed are with respect to chassis and, except where alternative instructions are given, should be measured with the MOD SELECTOR switch set to INT MOD—A.M., the RANGE MC/S switch to 108–220, the SET CARRIER control to maximum, and the SET MOD control to minimum.

TABLE 4

Valve No.	*Va*	*Vg2*	*Vk*
V1	250	50	1·3
V2	150	150	9
V3	150	75	—
V4	55	55	—
V5	250	250	7·5 40†
V6	83	120	—
V7 (amp)*	250	—	2·3
V7 (osc)*	250	—	—
V8	100	110	—
V10	120	120	—
V12	100	110	—

**When checking V7 voltages, set the RANGE MC/S switch to* 1·5–13·5.

†*The cathode potential of V5 increases to* 40 *volts when the MOD SELECTOR switch is set to INT MOD—F.M.*

5.6 REPLACEMENT OF VALVES AND CRYSTALS

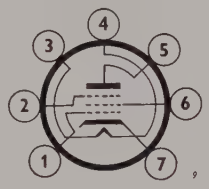
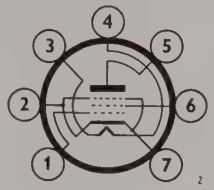
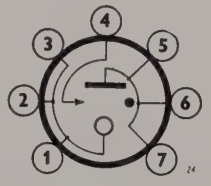
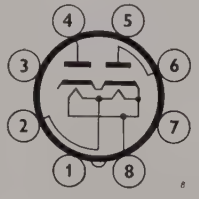
The types of valve used in the instrument, their base connections, and some guidance as to suitable alternatives if the types originally fitted are not readily available, are given in Table 5.

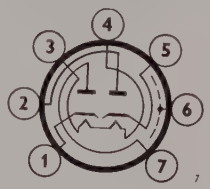
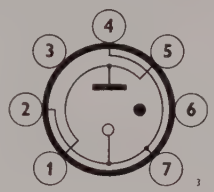
The valves and crystals may normally be replaced without special selection. Valves V1, V5, V9, V11, and V13 to V15 are immediately accessible on removing the instrument from its case. To gain access to the 333·3-kc/s oscillator crystal, X1, and to the remaining valves, remove the R.F. Unit screening cover. The crystal rectifier, X2, forms part of the OUTPUT VOLTAGE attenuator assembly and can be removed by the procedure detailed in Section 5.4.3.

Replacement of valves or crystals may necessitate either the reselection of associated components or readjustment of associated preset controls; aspects of this reselection and readjustment are discussed in the following Section.

TABLE 5

Any valve which becomes faulty should preferably be replaced by a valve of the type originally supplied in the instrument and designated in the following table. If this is not possible, the additional data given by the table may be used as a guide to suitable alternatives.

Valve	*Type*	*Base*	*British Commercial Equivalent*	*British Services Equivalent*	*U.S. Equivalent*
V1, V2	Brimar 6AK6 Power Pentode	 (B7G)		CV1762	6AK6
V3, V4, V6, V8, V10, V12	Mullard EF95 H.F. Pentode	 (B7G)	6AK5	CV850	6AK5
V5	Brimar 6AU6 Pentode	(B7G)		CV2524 CV4023	6AU6
V7	Brimar 12AT7 Double Triode	(B9A)	ECC81	CV455	12AT7
V9	Marconi QS150/15 Voltage Stabilizer	 (B7G)	OA2*	CV287 CV1832* CV4020*	OA2*
V11	Brimar 5Z4G Full-Wave Rectifier	 (IO)	R52 GZ30 52KU U50	CV1863	5Z4G

Valve	*Type*	*Base*	*British Commercial Equivalent*	*British Services Equivalent*	*U.S. Equivalent*
V13, V15	Marconi D77 Double Diode	 (B7G)	6AL5 6D2 D152 DD6 EB91	CV140	6AL5
V14	Mullard 85A2 Voltage Stabilizer	 (B7G)	QS1209 QS83/3	CV449	5651

**The base connections for these voltage stabilizers are different from those of the type QS150/15 (CV287). The holder for V9 in the TF 995A/2M has been specially wired so that, without rewiring, any of the voltage stabilizers listed as alternatives can be used.*

5.7 PRESET AND SPECIALLY SELECTED COMPONENTS

During the factory calibration of the instrument, certain of its performance characteristics are brought within fine limits by means of preset components. Following the replacement or aging of certain fixed components, it may become necessary to repeat the calibration procedure by which the presets were adjusted.

The Description column of the Spares Ordering Schedule shows which of the components are of the preset type; components which are individually selected are distinguished in that column by a single asterisk.

If, in servicing a TF 995A/2M, it is necessary to replace any of these components, it is also necessary, if the performance or accuracy of the instrument is not to be impaired, to repeat the factory calibration procedure by which the components were originally selected.

Section 5.8 gives a range of tests by which the main points of the performance of the instrument can be checked; this section also deals with the adjustment of preset components and with the choice of value for individually selected components.

It will be appreciated that it may sometimes be necessary to reselect a selected component even though that component itself has not been found faulty and replaced in initial servicing operations.

To take an example—the internal modulation oscillator is tuned by T1 and C6. In manufacture, C6 is selected to give an oscillator frequency of 1,000 c/s $\pm$ 5%. In servicing the instrument it might be found that T1 was faulty but that C6 was

TABLE 6

Component	*Section Describing Adjustment or Selection*	*Component*	*Section Describing Adjustment or Selection*
R2	5.8.11	R69	5.8.14
R5	5.8.12	R70	5.8.8
R6	5.8.12	R114	5.8.13
R7	5.8.12	R124	5.8.20
R9	5.8.12	C6	5.8.9
R11	5.8.12	C35	5.8.5
R12	5.8.12	C40	5.8.7
R13	5.8.12	C47	5.8.6
R14	5.8.12	C59	5.8.7
R19	5.8.10	C66	5.8.6
R24	5.8.11	C76	5.8.6
R39	5.8.18	C83	5.8.6
R50	5.8.13	T2	5.8.5
R63	5.8.17	T3	5.8.6
R65	5.8.14	L8	5.8.4
R66	5.8.14	L18	5.8.6
R67	5.8.14	L22	5.8.6
R68	5.8.14	L23	5.8.6

not. If T1 was replaced then it would be quite likely that with the original C6 the oscillator frequency would be outside the specified limits of ± 5% and that a new value of capacitance would have to be chosen.

It therefore follows that, in all servicing involving replacement of components, the user should consider carefully the possible effects on the performance of the stage or stages involved.

Table 6 on page 27 lists the circuit reference numbers of both types of component together with the numbers of the sections in which their adjustment or selection is described.

5.8 SCHEDULE OF TESTS

The following information, based on abstracts from the internal Factory Test Schedule, is included to enable the user to carry out a series of tests by which the main points of performance of the instrument can be checked; it also gives details concerning the adjustment to preset components and the choice of value for individually selected components.

5.8.1 APPARATUS REQUIRED

(a) 750-volt Insulation Tester.

(b) Avometer, model 8.

(c) Wave Analyser; Marconi Type TF 455 (Series).

(d) Signal Generator, with standardized output; Marconi Types TF 801 (Series) or TF 995 (Series).

(e) Valve Voltmeter; Marconi Types TF 428 (Series), TF 958, TF 1041 (Series), TF 1100, or TF 1300.

(f) A.M. Communications Receiver, covering the range 1·5 to 220 Mc/s.

(h) Audio-Frequency Oscillator; Marconi Types TF 195 (Series), TF 885 (Series), TF 894 (Series), or TF 1101.

(i) Cathode-Ray Oscilloscope; Marconi Type TF 1330 (Series).

(j) Deviation Meter; Marconi Type TF 791 (Series).

Note: *For the F.M. on C.W. check* (*Section* 5.8.20), *where deviations of less than* 50 *c/s have to be measured, it is essential that the deviation meter should be modified to operate from battery supplies, or incorporate facilities allowing its local oscillator to be brought under crystal control.*

5.8.2 INSULATION

(*Apparatus required: Item a*)

Test the insulation between each pin of the supply plug and chassis with SK1 engaged with PL1. The reading should not normally be less than 40 MΩ.

5.8.3 HUM LEVEL

(*Apparatus required: Item c*)

Measure the 100-c/s hum level using a wave analyser isolated from the TF 995A/2M by means of a suitable capacitor. The hum level should not normally exceed 20 mV as measured at the H.T.1 point.

5.8.4 CRYSTAL OSCILLATOR

(*Apparatus required: Item e*)

Plug head telephones into the CRYSTAL CHECK socket and turn the TUNE control until an audio beat is heard; adjust the core of L8 for maximum intensity of the audio beat note.

Measure the voltage across R27 with a valve voltmeter; it should normally be between 8 and 10 volts.

5.8.5 BASIC OSCILLATOR

(*Apparatus required: Items e and f*)

Set the MOD SELECTOR switch to C.W. and the main tuning dial to 27 Mc/s. Using a receiver as indicator, adjust C35 until the circuit oscillates at 9·0 Mc/s. Set the main tuning dial to 13·5 Mc/s, and adjust the core of T2 until the circuit oscillates at 4·5 Mc/s. Repeat these two adjustments.

Measure the r.f. voltages at the grid and anode of V3 using a valve voltmeter. These should be of the following order:—

	4·5 Mc/s	9 Mc/s
Grid	2 volts	4 volts
Anode	14 volts	24 volts

Recheck the tuning adjustments against the crystal by means of high-resistance headphones plugged into the CRYSTAL CHECK socket. Fourteen check points should be heard. Check that the oscillator output is maintained when the dial is set to 27·5 Mc/s.

5.8.6 FREQUENCY MULTIPLIERS

(*Apparatus required: Item f*)

(1) 13·5- to 27-Mc/s band

Set the MOD SELECTOR switch to C.W., the RANGE switch to 13·5–27 Mc/s, and the SET CARRIER control fully clockwise.

Set the main dial to 13·5 Mc/s, and adjust the core of T3 for maximum deflection on the panel meter.

Set the main dial to 27 Mc/s, and adjust C47 for maximum deflection on the meter.

Use the receiver to check that, at these two points, the stage is operating at 13·5 and 27 Mc/s respectively, and that the Signal Generator tunes to 27·5 Mc/s at the appropriate dial reading.

(2) 27- to 54-Mc/s band

Set the RANGE switch to 27–54, and adjust C66 and the spacing of the turns of L18 at 54 and 27 Mc/s respectively for maximum deflection on the panel meter.

Use the receiver to check that, at these two points, the stage is operating at 54 and 27 Mc/s respectively, and that the Signal Generator tunes to 55 Mc/s at the appropriate dial reading.

(3) 54- to 108-Mc/s band

Set the RANGE switch to 54–108, and adjust C76 and the spacing of the turns on L22 at 108 and 54 Mc/s respectively.

Use the receiver to check that, at these two points, the stage is operating at 108 and 54 Mc/s respectively, and that the Signal Generator tunes to 110 Mc/s at the appropriate dial reading.

(4) 108- to 220-Mc/s band

Set the RANGE switch to 108–220, and adjust C83 and the spacing of the turns on L23 for maximum reading on the TF 995A/2M output meter at 216 and 108 Mc/s respectively.

Use the receiver to check that, at these two points, the stage is operating at 216 and 108 Mc/s respectively, and that the Signal Generator tunes to 220 Mc/s at the appropriate dial reading.

5.8.7 1·5- TO 13·5-Mc/s BAND

(*Apparatus required: Item f*)

This test must be made with the r.f. unit cover in position.

By means of a suitable jack plug, connect a pair of head telephones to the CRYSTAL CHECK socket.

Set the RANGE switch to 1·5–13·5, and adjust the TUNE control to bring the 30 Mc/s main dial marking (on the 27–54 Mc/s arc) to the cursor; then, using the crystal calibrator, tune for zero beat.

With the SET CARRIER control in its fully clockwise position, adjust C40 and C59 alternately to give minimum deflection on the panel meter. These capacitors are accessible through two holes, slightly larger than the ventilation holes, in the top of the r.f. unit cover.

Connect the output of the Signal Generator to a receiver, and tune the receiver to some convenient accurately-known frequency between 1·5 and 13·5 Mc/s.

Set the main dial of the TF 995A/2M to this frequency, and adjust C40 for maximum receiver response.

In the absence of any other frequency standard, the receiver tuning may be standardized at frequencies between 4·5 and 9 Mc/s by loosely coupling its input to the basic oscillator of the TF 995A/2M. This oscillator should first be standardized against the internal crystal calibrator, the basic-oscillator frequency being given by dividing by three the indication on the 13·5–27 scale.

5.8.8 R.F. OUTPUT VOLTAGE ACCURACY

(*Apparatus required: Items d, e, and f*)

This test should be carried out with the instrument in its case.

Using a receiver as indicator, compare the output voltage with that of a standardized signal generator. If a constant error exists, it is probably due to a faulty monitor diode X2. This diode should have a backward resistance of 8 kΩ or greater when checked with a sensitive multi-range test meter, e.g. Avometer Model 8. If X2 is replaced, it will be necessary to select a new value for R70 in order to bring the output level within the limits of 0·89 to 1·12 of nominal up to 100 Mc/s, and 0·795 to 1·25 of nominal up to 220 Mc/s.

Check at the following frequencies and levels: 25 Mc/s, 100 Mc/s, and 220 Mc/s; 100 mV and 10 μV.

5.8.9 MODULATION OSCILLATOR

(*Apparatus required: Items e, h and i*)

Set the MOD SELECTOR switch to INT MOD—A.M., connect the output from the slider of the SET MOD potentiometer to the Y plates of a cathode-ray oscilloscope and the output of an a.f. oscillator to the X plates. Check the frequency of oscillation by the lissajous-figure method, and, if outside the limits of 950 to 1,050 c/s, select a new value for the tuning capacitor C6.

Measure the output voltage at the SYNC terminal with a valve voltmeter. It should not be less than 100 volts.

5.8.10 F.M. DISTORTION

(*Apparatus required: Items c and j*)

Set the DEVIATION—NORMAL/HIGH switch to NORMAL, the DEVIATION RANGE switch to 75 kc/s, the MOD SELECTOR switch to INT MOD—F.M., and the RANGE switch to 13·5–27; then adjust the SET CARRIER control to give a convenient deflection on the TF 995A/2M panel meter.

Connect the output cable directly to a carrier deviation meter, tune both instruments to 20 Mc/s, and adjust the TF 995A/2M attenuators for maximum output.

Adjust the SET MOD control to produce 75 kc/s deviation, and check that the positive and negative deviations as indicated on the deviation meter are equal. If they are unequal, select a value for R19 to produce equal positive and negative deviations.

Apply the demodulated f.m. signal from the deviation meter to a wave analyser, and measure the total distortion at carrier frequencies of 13·5, 27, 90, and 220 Mc/s. The total f.m. distortion should not exceed 2%.

5.8.11 DEVIATION RANGE ADJUSTMENTS

(*Apparatus required: Item j*)

Set the DEVIATION—NORMAL/HIGH switch to NORMAL, the DEVIATION RANGE switch to 75 kc/s, the MOD SELECTOR switch to INT MOD—F.M., and adjust the SET CARRIER control to bring the meter pointer to SET R.F. Set the OUTPUT VOLTAGE and MULTIPLY BY attenuators to 100 dB, connect the output cable directly to a deviation meter, and tune both instruments to the same frequency.

Adjust the SET MOD control to maximum and select a value for R2 which will produce a deviation of approximately 85 kc/s, as measured on the deviation meter.

Set the DEVIATION RANGE switch to 25 kc/s and select a value for R24 so that a deviation of approximately 28 kc/s is obtained with the SET MOD control at its maximum position.

5.8.12 F.M. DEVIATION

(*Apparatus required: Item j*)

Set the DEVIATION—NORMAL/HIGH switch to NORMAL, the DEVIATION RANGE switch to 75 kc/s, the MOD SELECTOR switch to INT MOD—F.M., and the SET CARRIER control to give a convenient deflection on the TF 995A/2M output meter. Connect the output cable directly to a carrier deviation meter; set the TF 995A/2M attenuator controls to give maximum output, and tune both instruments to 13·5 Mc/s.

Depress the METER READS switch to F.M., and adjust the SET MOD control to give a meter indication of 75 kc/s deviation. By means of the carrier deviation meter, check that the deviation at 13·5 Mc/s is 75 kc/s $\pm$ 5% and that this accuracy is maintained at 27·5 Mc/s. If the deviation is outside this accuracy, retune the Signal Generator and the deviation meter to 13·5 Mc/s, and select a value for R6 to give 75 kc/s deviation at this frequency.

Check that the deviation is within the limits stated at 27·5 Mc/s. If it is not, make slight adjustment to the angular position of the slider of R7 (relative to that of the tuning gang) to obtain equal deviations at 13·5 Mc/s and 27·5 Mc/s. Subsequent slight readjustment of R6 may then be necessary in order to maintain deviation accuracy.

Check the deviation on the 27- to 54-Mc/s band to the same limits of accuracy as for the lower band. If it is outside these limits, select new values for R13 and if necessary R14, to obtain 75 kc/s deviation at 27 Mc/s. Check that this deviation is maintained at 55 Mc/s.

Check the deviation accuracy on the 54- to 108-Mc/s band. If it is outside the limits stated select new values for R11 and if necessary R9, to bring the deviation at 54 and 110 Mc/s to the required accuracy.

Check the deviation accuracy on the 108- to 220-Mc/s band. If it is outside the limits stated, select new values for R5 and if necessary R12, to bring the deviation at 108 and 220 Mc/s to the required accuracy.

If a deviation meter is not available, the following method may be used to determine the frequency deviation. This method—the disappearing carrier method—depends upon the fact that the carrier, as opposed, of course, to the sidebands, disappears when the modulation index μ (the ratio of the frequency deviation δF to the modulation frequency f) has values of 2·4, 5·52, 8·65, 11·79, etc. Therefore, if the modulation frequency, f, is known, since deviation, δF, is equal to μf, deviation can be simply calculated when μ is known—i.e. at a carrier disappearance point. For example, if the applied modulation has a frequency of 10 kc/s and the deviation is progressively increased until the carrier disappears, the deviation must be $2{\cdot}4 \times 10 = 24$ kc/s, and again $5{\cdot}52 \times 10 = 55{\cdot}2$ kc/s.

A deviation check at 75 kc/s can be obtained at the second disappearance with a modulation frequency of 13·6 kc/s.

To determine these points, apply the output of the TF 995A/2M to a narrow-band (communication) a.m. receiver and tune the latter to the unmodulated output frequency of the TF 995A/2M. Set the beat oscillator of the receiver to give an audio note; then frequency modulate the Signal Generator at a fairly high frequency outside the passband of the a.m. receiver—such as 10 kc/s—starting from zero deviation and increasing the deviation until the beat with the carrier disappears. At this point, the actual deviation can be calculated as described above.

5.8.13 INCREMENTAL FREQUENCY

(*Apparatus required: Items h and i*)

Check the calibration of the INC. FREQ. dial in the following manner:—

(1) By means of a suitable jack plug, connect a pair of head telephones to the CRYSTAL CHECK socket; set the MOD SELECTOR switch to C.W.; then set the INC. FREQ. control to its centre-zero position and short-circuit the slider of its potentiometer, R112, to chassis.

(2) Adjust the TUNE control to bring the frequency of the r.f. oscillator to some convenient crystal check point near the low-frequency end of the range, and tune carefully to zero beat.

(3) Disconnect the short-circuit between the slider of R112 and chassis, and check that zero beat occurs when the INC. FREQ. control is within 2 kc/s of its centre-zero position.

(4) If zero beat does not occur with the control within 2 kc/s of its zero setting, check that the dial is positioned on its spindle so that the 0 coincides with the cursor when the potentiometer is at its mid-travel position; then select a value for R50 to bring the frequency to zero beat with the INC. FREQ. dial reading zero.

(5) Having obtained satisfactory operation at zero frequency-shift position, disconnect the telephones and connect in their place the Y input of a cathode-ray oscilloscope. Connect an a.f. oscillator to the X input of the oscilloscope, and adjust the frequency of this oscillator to exactly 3·33 kc/s.

(6) Using the lissajous-figure method, check the accuracy of the incremental dial at each calibration point. A calibrated movement of 10 kc/s on the incremental dial corresponds to an actual shift of the r.f. oscillator frequency of 3·33 kc/s.

(7) If necessary, select a value for R114 to bring the calibration of the INC. FREQ. dial to an accuracy of 10%.

5.8.14 DEVIATION MONITOR CIRCUIT

(*Apparatus required: Item j*)

Check the accuracy of the deviation reading on the TF 995A/2M meter using a deviation meter or the disappearing carrier method described in Section 5.8.12. If the indication of the TF 995A/2M is not accurate, adjust R65. If adjustment of R65 does not correct the error on both ranges, proceed as follows.

Turn the SET MOD control to zero and the preset control R65 to mid-travel; set the DEVIATION RANGE switch to 25 kc/s and hold the METER READS switch to F.M. Select R69 to give zero reading on the TF 995A/2M meter.

Set the METER READS switch to C.W. and rotate the SET MOD control until 25 kc/s deviation is indicated on the deviation meter. Hold the METER READS switch to F.M. and select R67 so that the TF 995A/2M meter indicates the 25 kc/s deviation.

Set the DEVIATION RANGE switch to 75 kc/s, rotate the SET MOD control to zero, and hold the METER READS switch to F.M. Select R68 to give zero reading on the TF 995A/2M meter. Return the METER READS switch to C.W., and rotate the SET MOD control until 75 kc/s deviation is indicated on the deviation meter. Hold the METER READS switch to F.M. and select R66 to give full-scale reading on the TF 995A/2M meter.

Finally, recheck the deviation calibration at several points on each band.

5.8.15 HIGH DEVIATION

(*Apparatus required: Item j*)

Connect the output of the TF 995A/2M to a deviation meter and check that, when the TF 995A/2M is set for 9 kc/s deviation with the DEVIATION—NORMAL/HIGH switch set to NORMAL, the deviation, indicated on the deviation meter, rises to approximately the following values when the DEVIATION—NORMAL/HIGH switch is set to HIGH.

RANGE Mc/s	*HIGH Deviation for 9 kc/s NORMAL*
1·5–13·5	18 kc/s
13·5–27	9 kc/s
27–54	18 kc/s
54–108	36 kc/s
108–220	72 kc/s

5.8.16 EXTERNAL F.M.

(*Apparatus required: Items h and j*)

Connect the output of a beat frequency oscillator to the EXT MOD and E terminals and set it to deliver 30 volts r.m.s. at 1 kc/s. Set the MOD SELECTOR switch to EXT MOD—F.M., the DEVIATION—NORMAL/HIGH switch to NORMAL, hold the METER READS switch to F.M., and adjust the SET MOD control for 75 kc/s deviation. Tune the beat frequency oscillator over the range 50 c/s to 15 kc/s and check that the input required for 75 kc/s deviation does not vary by much more than ± 1 dB.

Feed the output of the TF 995A/2M to the deviation meter and repeat the operation using the deviation meter as indicator; check that not more than ± 1 dB variation in input is required to maintain the deviation at 75 kc/s.

5.8.17 INTERNAL A.M.

(*Apparatus required: Items c, f, and i*)

Apply the output of the TF 995A/2M to a frequency changer circuit which is followed by an i.f. amplifier and cathode ray oscilloscope; the i.f. amplifier should have a centre frequency which will allow its output to be viewed directly on the c.r.o. Set the MOD SELECTOR switch to INT MOD—A.M. and adjust the SET MOD control for 30% modulation as measured on the c.r.o. screen using the formula:—

$$M(\%) = \frac{D\ max - D\ min}{D\ max + D\ min} \times 100$$

where D max = the peak-to-peak dimensions of the c.r.o. display.

D min = the trough-to-trough dimensions of the c.r.o. display.

Hold the METER READS switch to A.M. and check that the meter reading is correct. If not, select a new value for R63.

Using the wave analyser check that the total distortion of the detected output appearing across R70 does not, in general, exceed 5% at 30% modulation.

5.8.18 EXTERNAL A.M.

(*Apparatus required: Items f, h, and i*)

Connect the output of a beat frequency oscillator to the EXT MOD and E terminals, and adjust it to produce approximately 30 volts r.m.s. Set the MOD SELECTOR switch to EXT MOD—A.M. and adjust the SET CARRIER control so that the meter reads SET R.F. Adjust the SET MOD control to produce 30% modulation depth at 1,000 c/s, as measured on an oscilloscope in the manner outlined in Section 5.8.17. Tune the beat frequency oscillator from 50 c/s to 10 kc/s and check that the input required to produce 30% modulation is flat within 1 dB relative to 1,000 c/s. If not, select a value for R39 which fulfils these conditions.

5.8.19 SPURIOUS A.M.

(*Apparatus required: Item i*)

Set the TF 995A/2M for 10% a.m. at 20 Mc/s and measure the a.c. voltage appearing across R70. Set to 75 kc/s deviation and check that the voltage across R70 is not greater than before.

5.8.20 SPURIOUS F.M. ON C.W.

(*Apparatus required: Items c and j*)

When making this check, the instrument should be removed from its case but should be bonded to the power unit by a length of copper braid or heavy-gauge wire.

(1) Connect the generator output to the deviation meter. Note that since the deviation to be measured is as low as 50 c/s, it is essential that the deviation meter itself generates negligible spurious f.m. This can be achieved either by modifying the deviation meter to operate from batteries or by using a deviation meter whose local oscillator can be brought under crystal control.

(2) In order to detect the small amount of deviation accurately, connect the Wave Analyser to the ' L.F. Output ' terminals of the deviation meter.

(3) Set up the Signal Generator for, say, 10 kc/s internal f.m. deviation at a carrier frequency of 12 Mc/s.

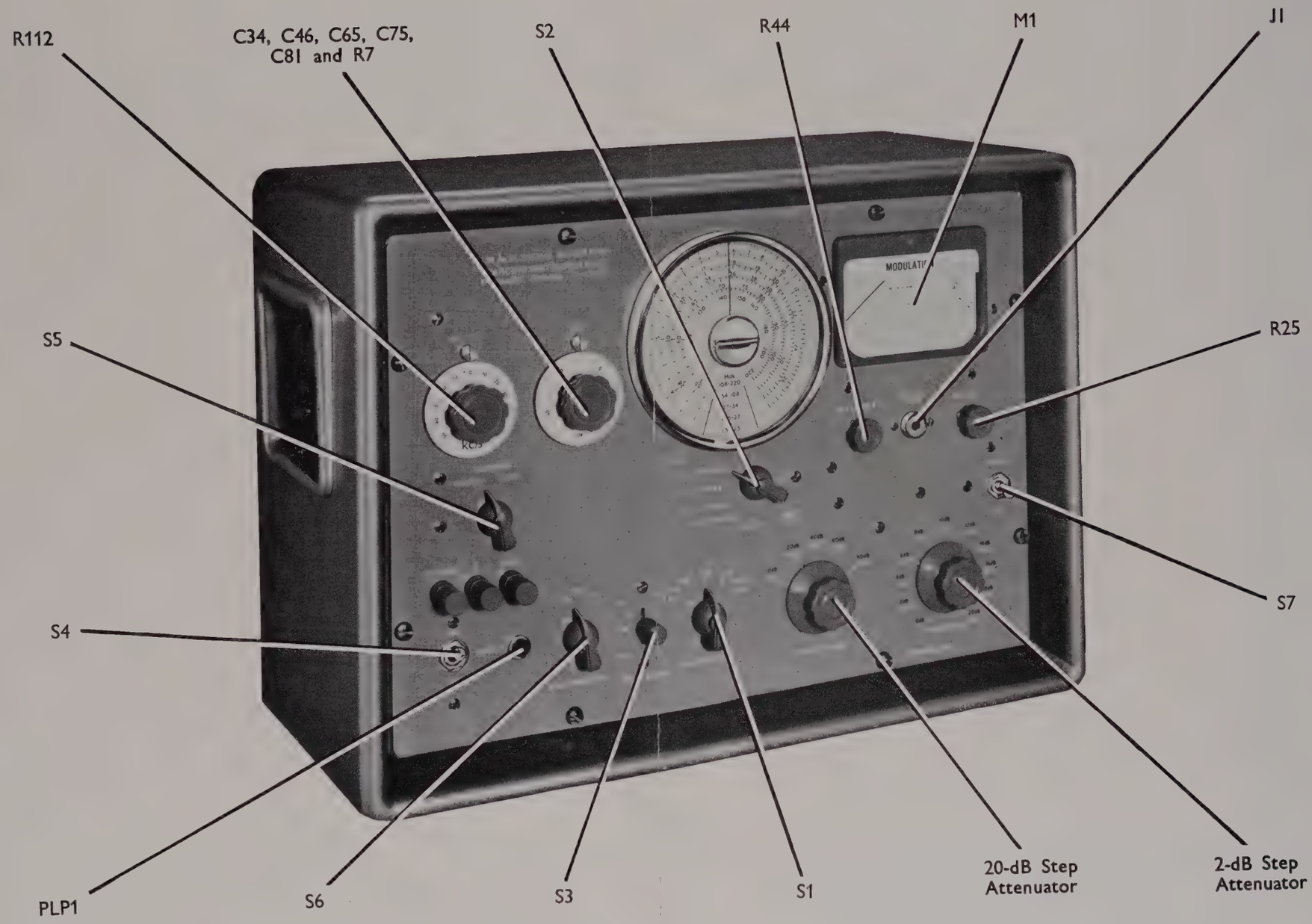
(4) Peak the wave analyser reading by tuning the deviation meter in the normal manner for a 12 Mc/s input and by tuning the Wave Analyser to the modulating frequency. From this reading, the Wave Analyser can be calibrated in terms of mV per kc/s deviation.

(5) Set the modulation selector to C.W. and, with the Carrier Deviation Meter still tuned to the 12 Mc/s carrier frequency, tune the Wave Analyser to the frequency of the power supply.

(6) Adjust R124 until the Wave Analyser indication is at a minimum. This potentiometer is accessible through a small hole in the side of the r.f. unit cover.

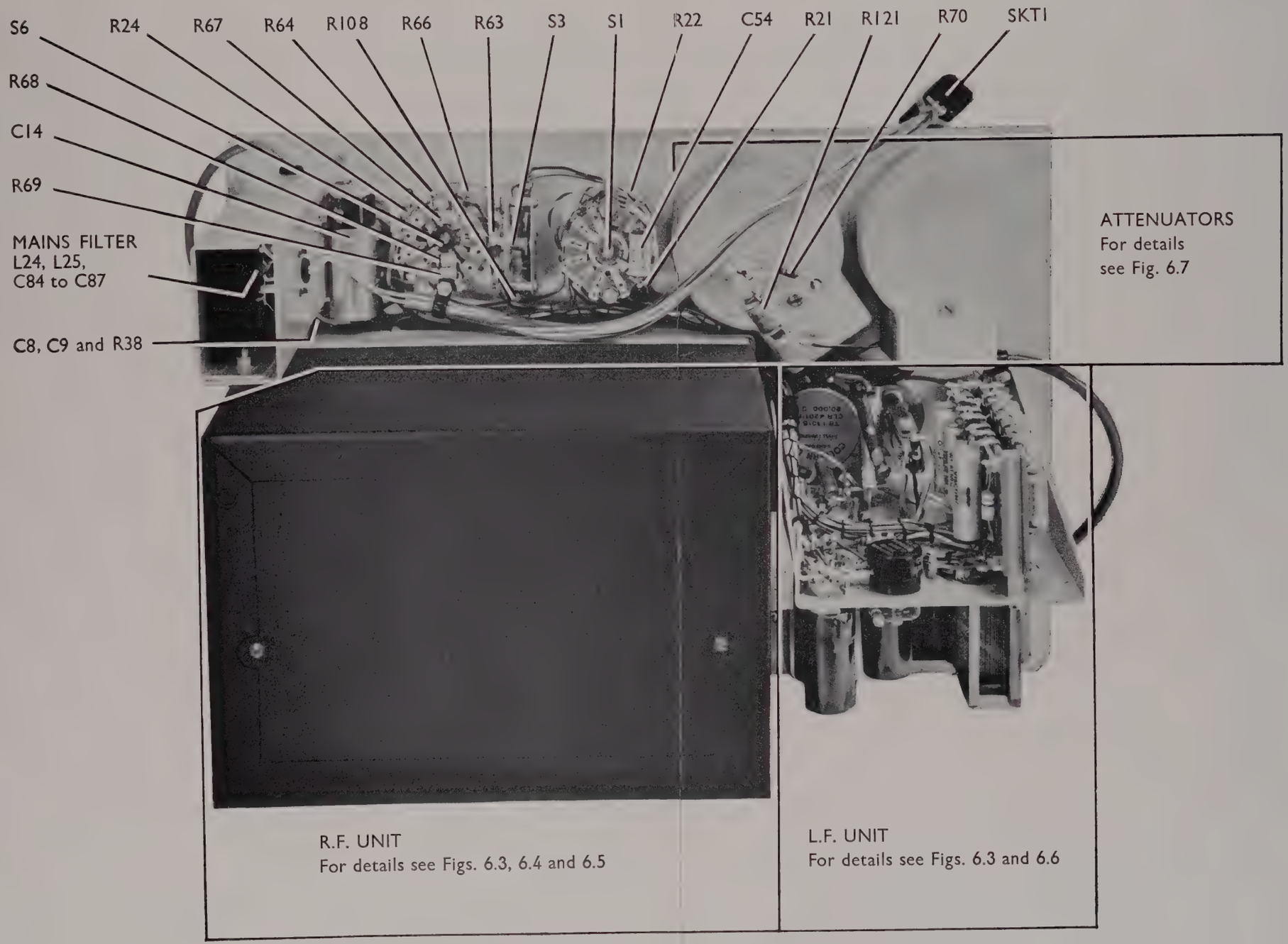
(7) Measure the levels of the hum and ripple components and, from the geometric sum, calculate the deviation. The deviation should be less than 50 c/s.

(8) Repeat operations (5), (6), and (7) for a selection of frequencies up to 220 Mc/s. Below 100 Mc/s, the spurious deviation should be less than 50 c/s; between 100 and 220 Mc/s, the deviation should be less than 100 c/s.



FRONT PANEL

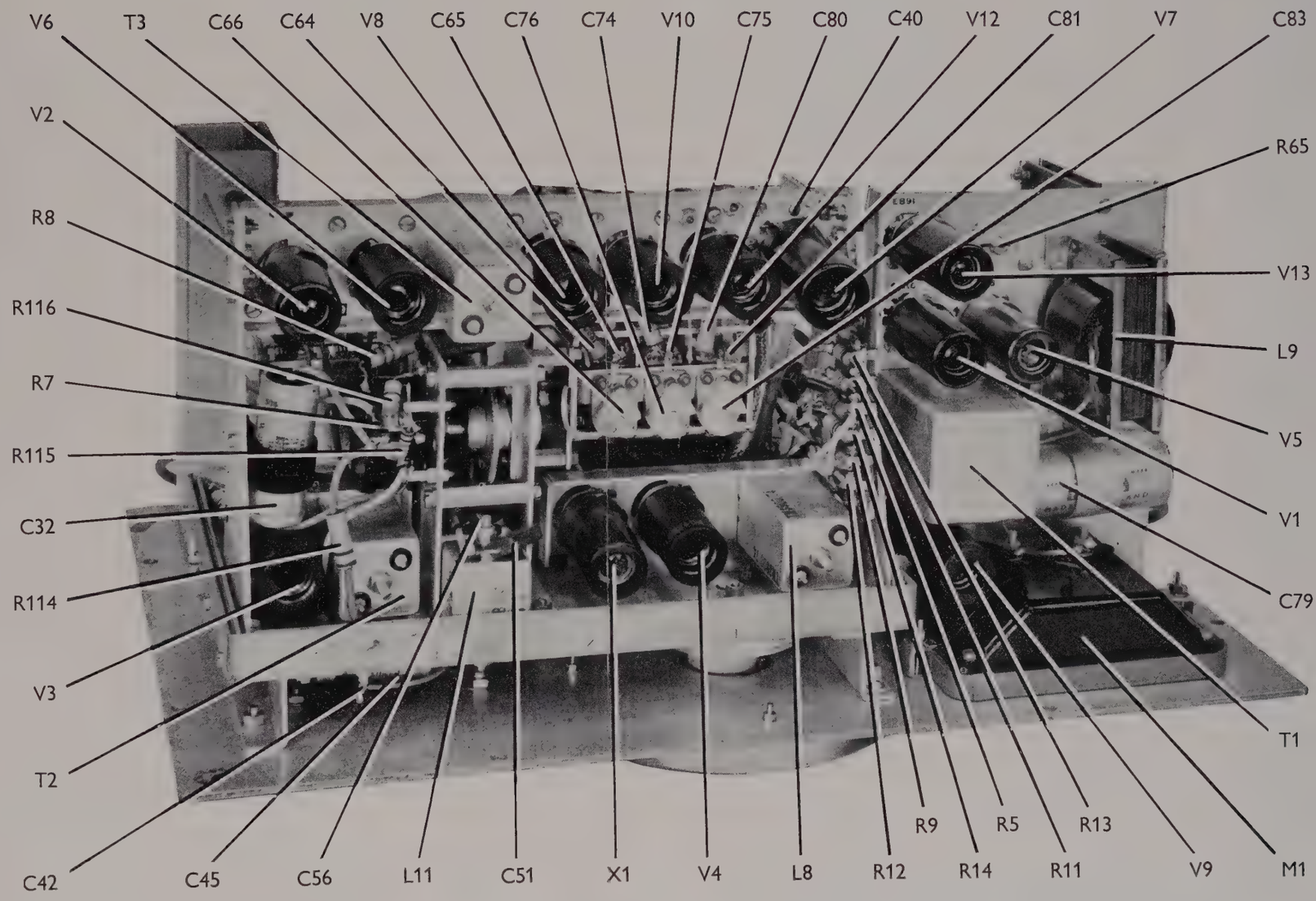
Fig. 6.1



OM 995A/2M
2-6/60

GENERAL UNDERSIDE VIEW FROM REAR
CASE REMOVED

Fig. 6.2

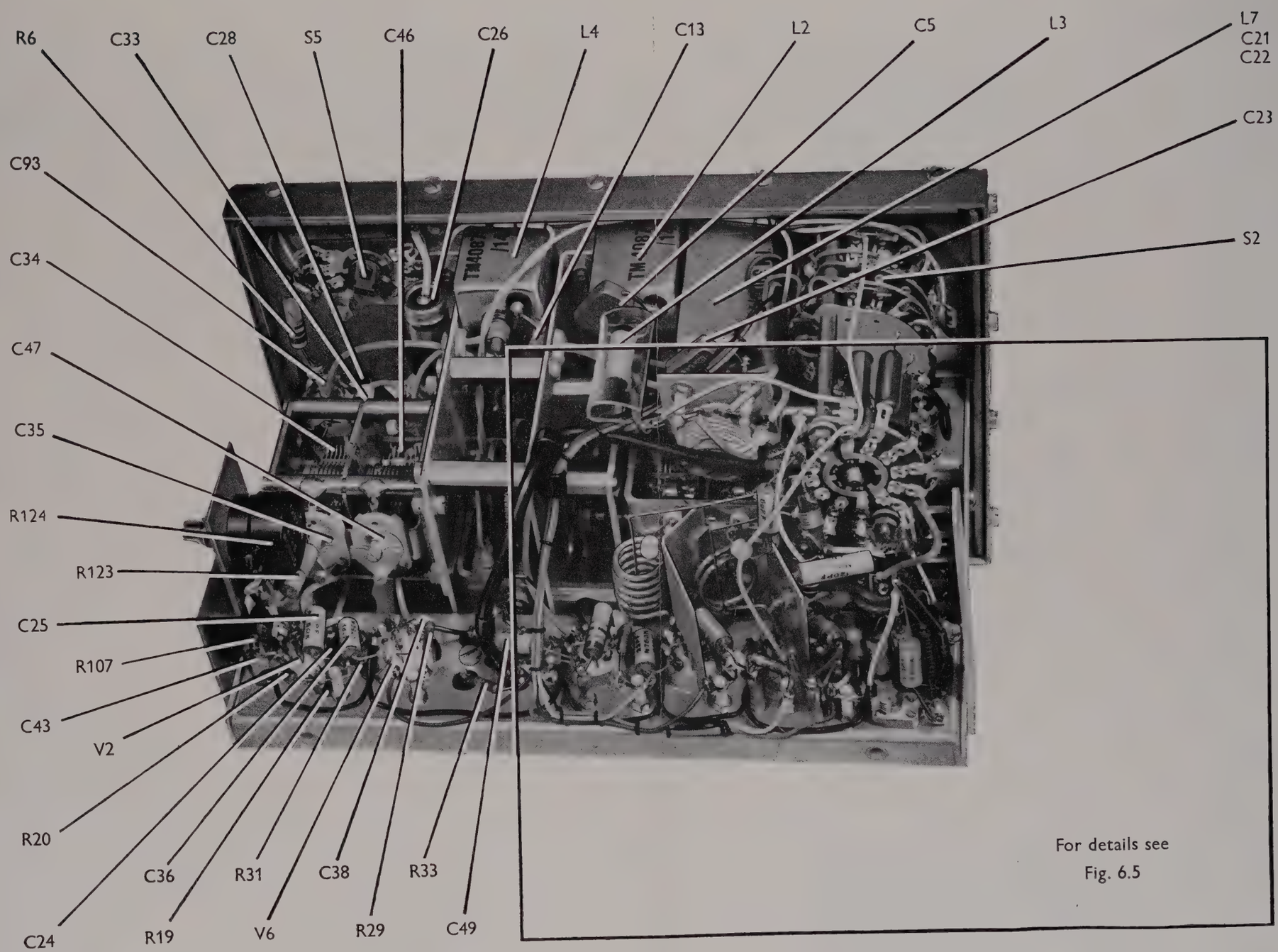


OM 995A/2M
2-6/60

L.F. AND R.F. UNITS

TOP VIEW WITH R.F. UNIT SCREENING COVER REMOVED

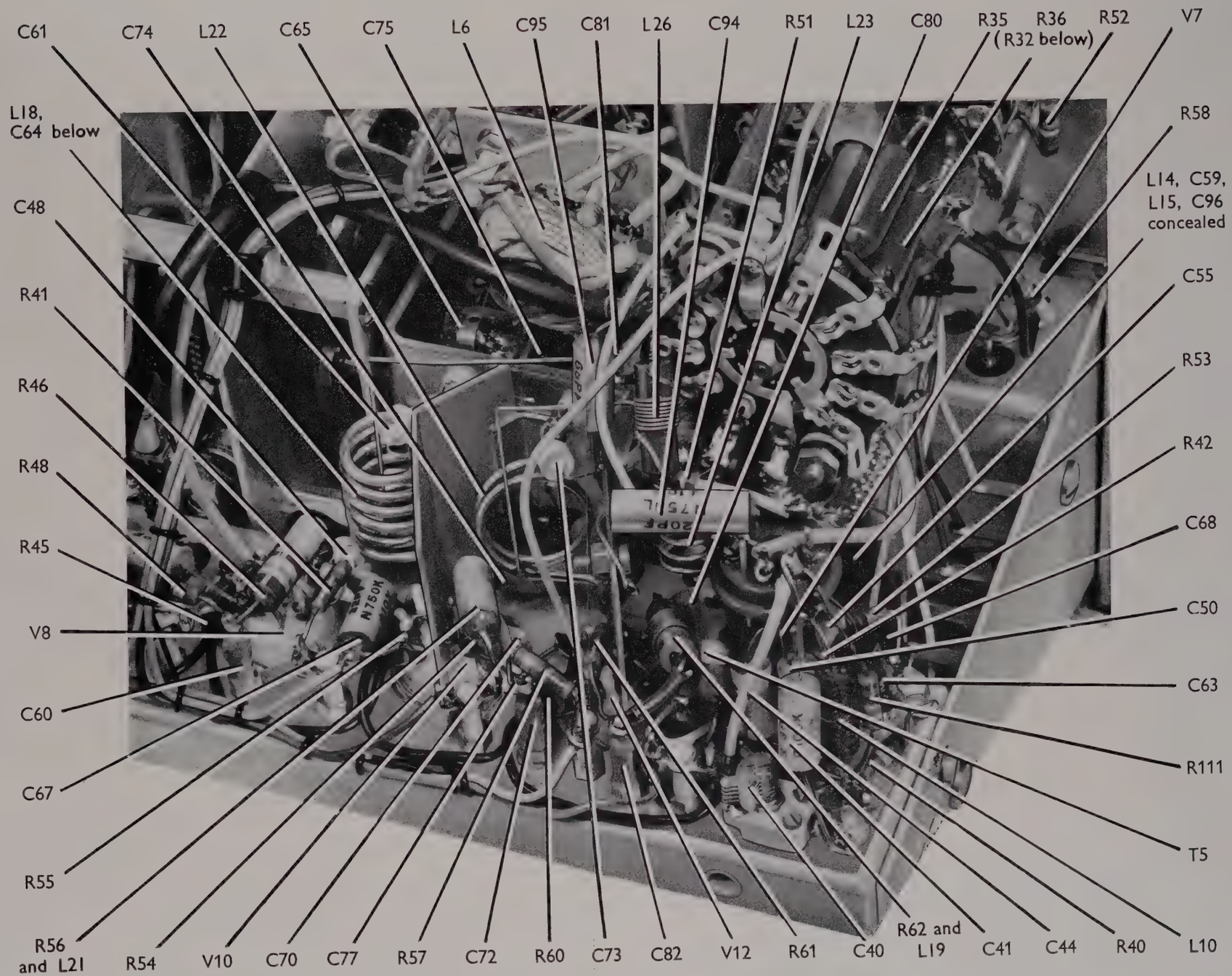
Fig. 6.3



OM 995A/2M
2-6/60

R.F. UNIT
GENERAL UNDERSIDE VIEW

Fig. 6.4

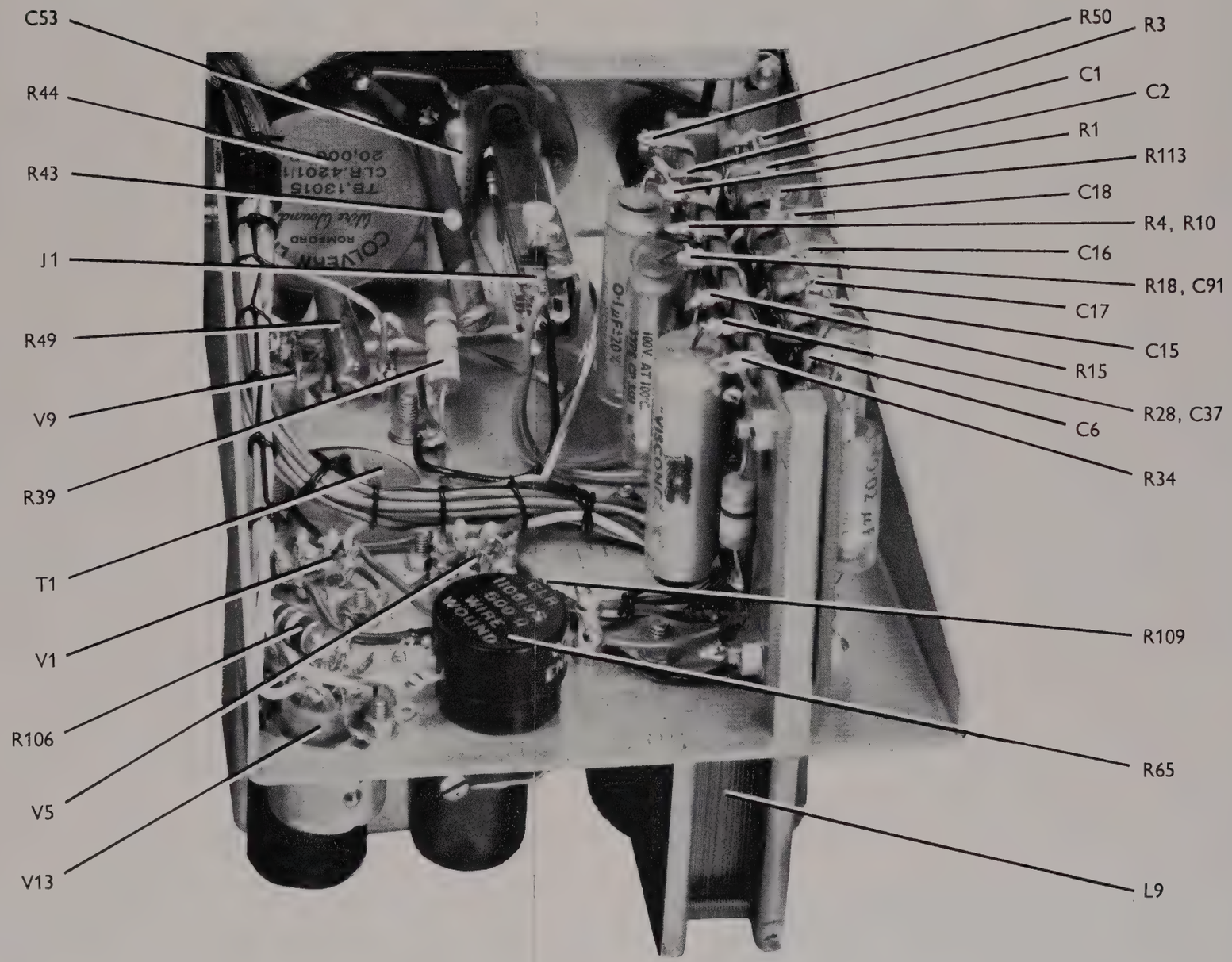


OM 995A/2M
2–6/60

R.F. UNIT

CLOSE UP OF PORTION OF UNDERSIDE

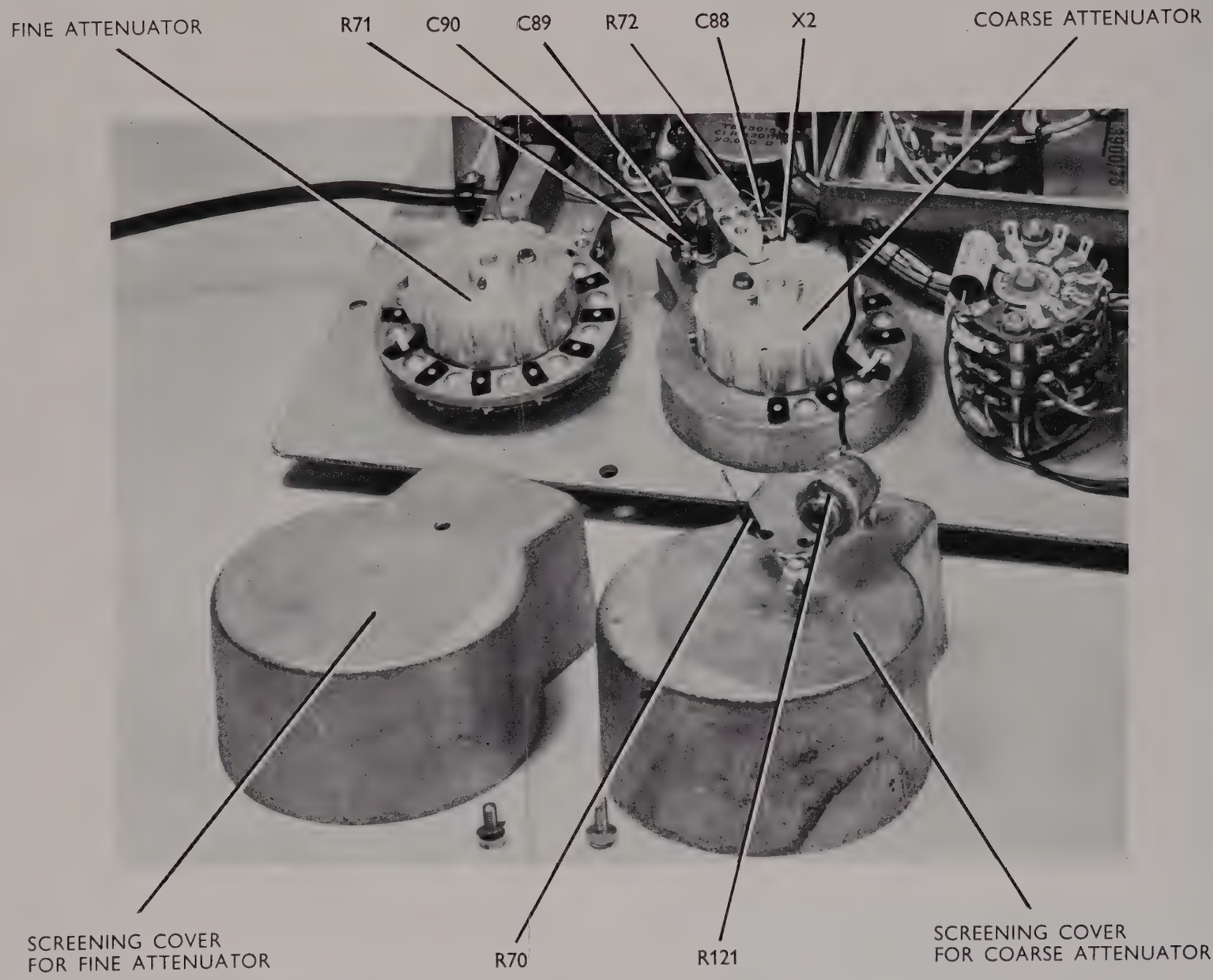
Fig. 6.5



OM 995A/2M
2-6/60

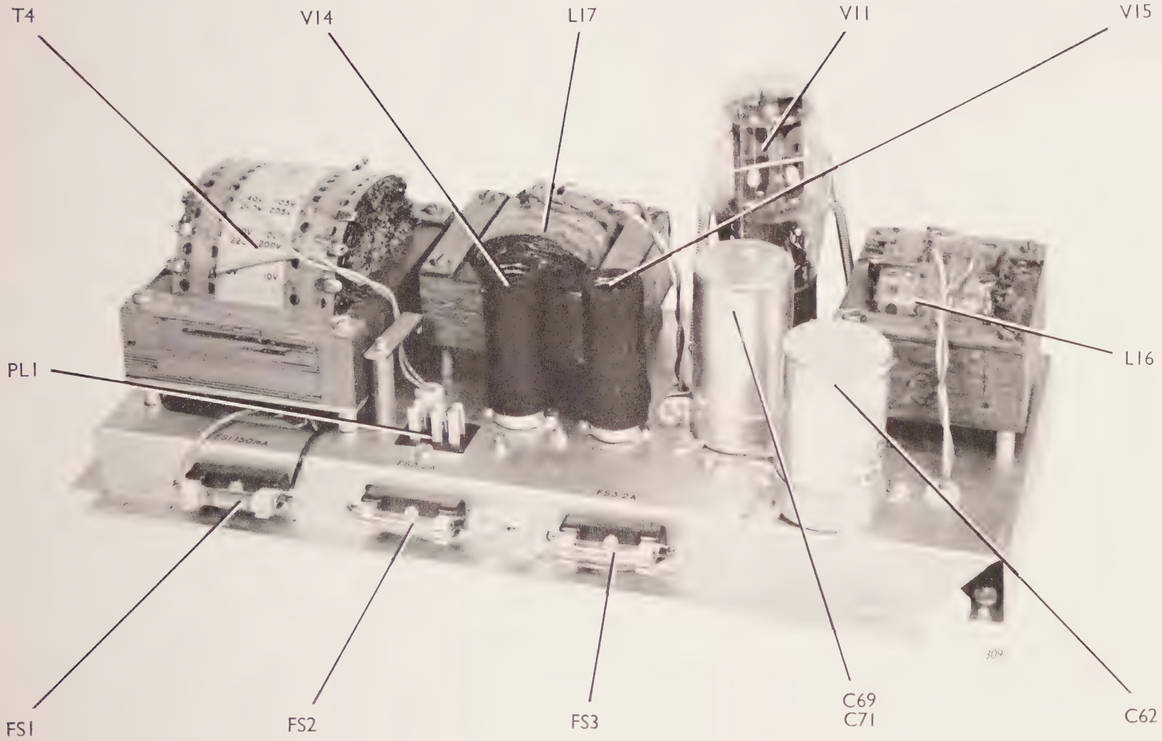
L.F. UNIT
UNDERSIDE VIEW

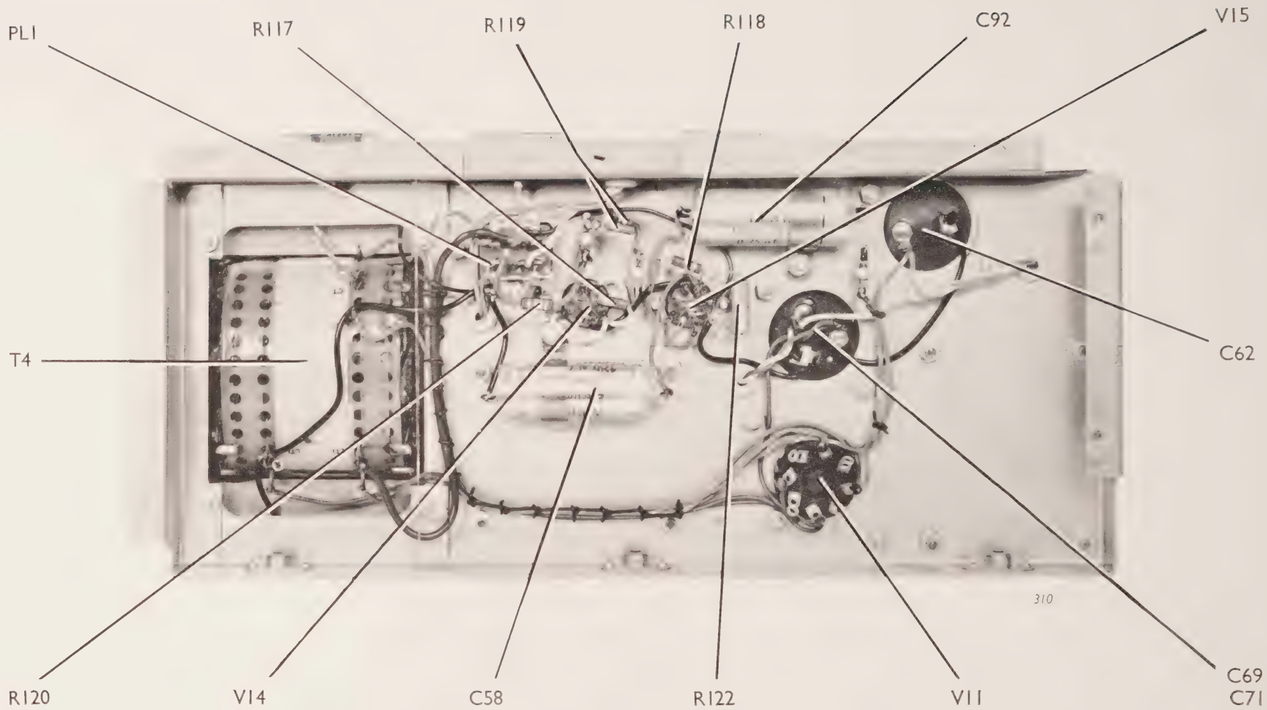
Fig. 6.6



ATTENUATORS
COVERS REMOVED

Fig. 6.7



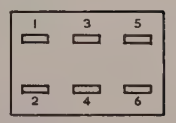


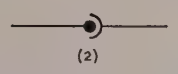
POWER UNIT

Fig. 6.8

PL 1

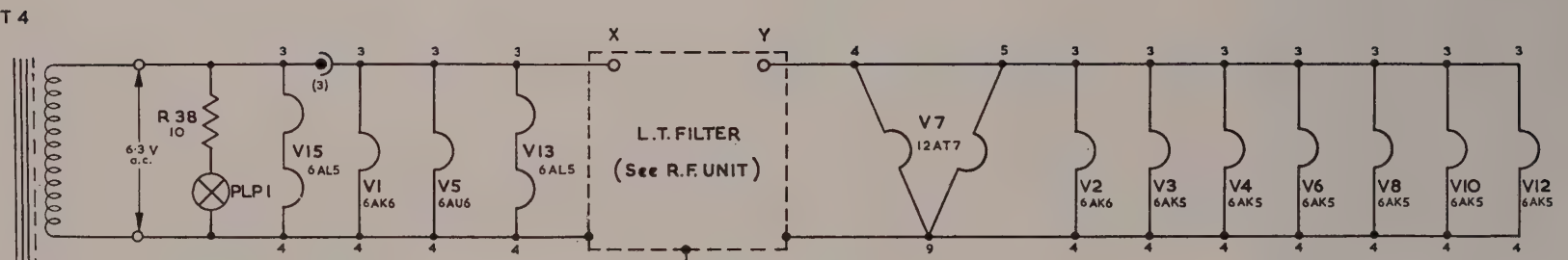
SKT 1

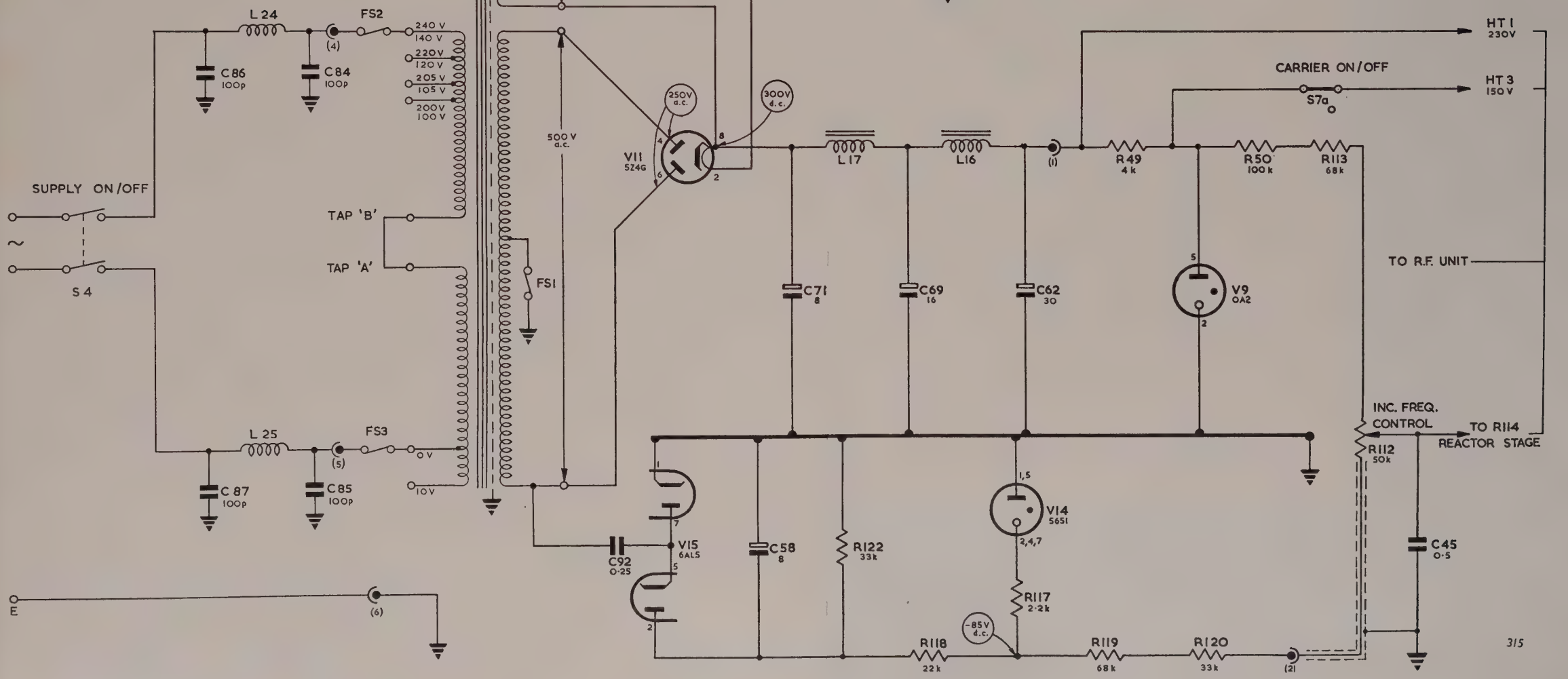




The above symbol refers to appropriate PLUG and SOCKET CONNECTIONS

HEATER CHAIN





NOTES

1. **COMPONENT VALUES**
   Resistors: No suffix = ohms. k = kilohms. M = megohms.
   Capacitors: No suffix = microfarads. p = picofarads.
   * Value selected during factory testing; nominal value shown.
2. **VOLTAGES**
   Measured relative to earth unless otherwise stated.

POWER UNIT

OM 995A/2M
2*-6/62
EX TD23080/2M IS.7

Fig. 8.2

7 Spares Ordering Schedule

for F.M./A.M. SIGNAL GENERATOR TYPE TF 995A/2M

When ordering replacement parts, always quote the TYPE NUMBER and SERIAL NUMBER of the instrument concerned.

To specify the individual parts required, state for each part the QUANTITY required and the appropriate SOS ITEM NUMBER.

For example, to order replacements for the 220-k Ω resistor, R4, and the 5-μμF capacitor, C73, quote as follows:—

Spares for TF995A/2M, Serial number 000000
1 off, SOS Item 4
1 off, SOS Item 190

It is important that the distinguishing code ' SOS ' preceding each item number should not be omitted.

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		RESISTORS	
1	R1	Composition, 470 k Ω ± 20%, ¼W.	4–TM4800/2
2	R2	Composition, 1·5 k Ω*, ½W.	PC66611/27
3	R3	Composition, 220 k Ω ± 10%, ½W.	PC66611/53
4	R4	Composition, 220 k Ω ± 10%, ¼W.	PC66609/48
5	R5	Composition, 27 k Ω*, ¼W.	PC66609/36
6	R6	Composition, 2·2 k Ω*, ½W.	PC66611/29
7	R7	Wire-wound, 50 k Ω Variable ± 10%, 3W.	18–TM4831/2
8	R8	Composition, 4·7 k Ω* ± 10%, ¼W.	PC66609/33
9	R9	Composition, 5·1 k Ω*, ½W.	7–TM4706/2
10	R10	Composition, 10 k Ω ± 10%, ½W.	PC66611/37
11	R11	Composition, 12 k Ω*, ¼W.	PC66609/32
12	R12	Composition, 4·7 k Ω*, ½W.	PC66611/33
13	R13	Composition, 3·9 k Ω*, ¼W.	PC66609/26
14	R14	Composition, 8·2 k Ω*, ½W.	PC66611/36
15	R15	Composition, 4·7 k Ω ± 10%, ¼W.	PC66609/27
16	R16	Wire-wound, 4·7 k Ω ± 5%, 7W.	113–TM4826/2
17	R18	Composition, 220 k Ω ± 10%, ¼W.	PC66609/47
18	R19	Composition, 1·2 k Ω*, ¼W.	PC66609/20
19	R20	Composition, 10 k Ω ± 5%, ¼W.	62–TM4826/2
20	R21	Composition, 68 k Ω ± 10%, ¼W.	PC66609/41
21	R22	Composition, 68 k Ω ± 10%, ¼W.	PC66609/41
22	R23	Composition, 56 k Ω ± 10%, ¼W.	PC66609/40
23	R24	Composition, 39 k Ω*, ¼W.	PC66609/38
24	R25	Composition, 20 k Ω Variable ± 20%, ¼W.	74–TF995A/2
25	R26	Composition, 15 k Ω ± 10%, ¼W.	PC66609/33

** Nominal value; actual value determined during calibration.*

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
26	R27	Composition, 2·7 MΩ ± 10%, ¼W.	PC66609/60
27	R28	Composition, 220 kΩ ± 10%, ¼W.	PC66609/47
28	R29	Composition, 6·8 kΩ ± 10%, ¼W.	PC66609/29
29	R30	Composition, 6·8 kΩ ± 10%, ¼W. (Part of Item 231)	PC66609/29
30	R31	Composition, 270 kΩ ± 10%, ¼W.	PC66609/48
31	R32	Composition, 100 Ω ± 10%, ¼W.	PC66609/7
32	R33	Composition, 2·2 kΩ ± 10%, ¼W.	PC66609/23
33	R34	Composition, 390 Ω ± 5%, ¼W.	11–TM4800/2
34	R35	Wire-wound, 15 kΩ ± 5%, 7W.	112–TM4826/2
35	R36	Wire-wound, 7·5 kΩ ± 5%, 7W.	111–TM4826/2
36	R37	Wire-wound, 5 kΩ ± 5%, 7W.	110–TM4826/2
37	R38	Composition, 10 Ω ± 10%, ½W.	PC66611/1
38	R39	Composition, 220 kΩ*, ½W.	PC66611/53
39	R40	Composition, 15 kΩ ± 10%, ¼W.	PC66609/33
40	R41	Composition, 6·8 kΩ ± 10%, ¼W.	PC66609/29
41	R42	Composition, 2·2 kΩ ± 10%, ¼W.	PC66609/23
42	R43	Composition, 10 kΩ ± 10%, 1W.	PC66621/37
43	R44	Wire-wound, 20 kΩ Variable, ±10%, 3W.	75–TF995A/2
44	R45	Composition, 100 kΩ ± 10%, ¼W.	PC66609/43
45	R46	Composition, 6·8 kΩ ± 10%, ½W.	PC66611/35
46	R47	Composition, 10 kΩ ± 10%, ½W.	PC66611/37
47	R48	Composition, 2·2 kΩ ± 10%, ¼W.	PC66609/23
48	R49	Wire-wound, 4 kΩ ± 5%, 7W.	72–TF995A/2
49	R50	Composition, 100 kΩ*, ½W.	PC66611/49
50	R51	Composition, 4·7 kΩ ± 10%, ¼W.	PC66609/27
51	R52	Composition, 220 kΩ ± 10%, ¼W.	PC66609/44
52	R53	Composition, 270 Ω ± 10%, ¼W.	PC66609/12
53	R54	Composition, 6·8 kΩ ± 10%, ¼W.	PC66609/29
54	R55	Composition, 68 kΩ ± 10%, ¼W.	PC66609/41
55	R56	Composition, 47 kΩ ± 20%, ½W.; includes L21.	TB23173/9
56	R57	Composition, 2·2 kΩ ± 10%, ¼W.	PC66609/23
57	R58	Composition, 100 kΩ ± 10%, ¼W.	PC66609/43
58	R59	Composition, 6·8 kΩ ± 10%, ¼W.	PC66609/29
59	R60	Composition, 100 kΩ ± 10%, ¼W.	PC66609/43
60	R61	Composition, 2·2 kΩ ± 10%, ¼W.	PC66609/23
61	R62	Composition, 33 kΩ ± 20%, ½W; includes L19.	TB23173/10
62	R63	Composition, 750 kΩ*, ¼W.	78–TF995A/2
63	R64	Composition, 470 Ω ± 10%, ¼W.	PC66609/15
64	R65	Wire-wound, 500 Ω Variable, ± 20%, ¼W.	PC67401/17
65	R66	Composition, 180 kΩ*, ½W.	PC66609/46

** Nominal value; actual value determined during calibration.*

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
66	R67	Composition, 56 k Ω*, ¼W.	PC66609/40
67	R68	Composition, 150 k Ω*, ¼W.	PC66609/45
68	R69	Composition, 47 k Ω*, ¼W.	PC66609/39
69	R70	Composition, 3·3 k Ω*, ¼W.	PC66609/24
70	R71	Composition, 1 k Ω ± 20%, ⅛W.	39–TM4297A
71	R72	Composition, 1 k Ω ± 20%, ⅛W.	39–TM4297A
72	R73	Carbon, High Stability, 82·5 k Ω ± 1%, ⅛W.	36–TM4297A
73	R74	Carbon, High Stability, 742 Ω ± 1%, ⅛W.	35–TM4297A
74	R75	Carbon, High Stability, 742 Ω ± 1%, ⅛W.	35–TM4297A
75	R76	Carbon, High Stability, 742 Ω ± 1%, ⅛W.	35–TM4297A
76	R77	Carbon, High Stability, 742 Ω ± 1%, ⅛W.	35–TM4297A
77	R78	Carbon, High Stability, 220 Ω ± 1%, ⅛W.	38–TM4297A
78	R79	Carbon, High Stability, 91·6 Ω ± 1%, ⅛W.	37–TM4297A
79	R80	Carbon, High Stability, 91·6 Ω ± 1%, ⅛W.	37–TM4297A
80	R81	Carbon, High Stability, 91·6 Ω ± 1%, ⅛W.	37–TM4297A
81	R82	Carbon, High Stability, 82·5 Ω ± 1%, ⅛W.	36–TM4297A
82	R83	Carbon, High Stability, 17·9 Ω ± 1%, ⅛W.	24–TM4298/2
83	R84	Carbon, High Stability, 17·9 Ω ± 1%, ⅛W.	24–TM4298/2
84	R85	Carbon, High Stability, 17·9 Ω ± 1%, ⅛W.	24–TM4298/2
85	R86	Carbon, High Stability, 17·9 Ω ± 1%, ⅛W.	24–TM4298/2
86	R87	Carbon, High Stability, 17·9 Ω ± 1%, ⅛W.	24–TM4298/2
87	R88	Carbon, High Stability, 17·9 Ω ± 1%, ⅛W.	24–TM4298/2
88	R89	Carbon, High Stability, 17·9 Ω ± 1%, ⅛W.	24–TM4298/2
89	R90	Carbon, High Stability, 17·9 Ω ± 1%, ⅛W.	24–TM4298/2
90	R91	Carbon, High Stability, 17·9 Ω ± 1%, ⅛W.	24–TM4298/2
91	R92	Carbon, High Stability, 17·9 Ω ± 1%, ⅛W.	24–TM4298/2
92	R93	Carbon, High Stability, 61·2 Ω ± 1%, ⅛W.	28–TM4298/2
93	R94	Carbon, High Stability, 332 Ω ± 1%, ⅛W.	26–TM4298/2
94	R95	Carbon, High Stability, 167 Ω ± 1%, ⅛W.	27–TM4298/2
95	R96	Carbon, High Stability, 167 Ω ± 1%, ⅛W.	27–TM4298/2
96	R97	Carbon, High Stability, 167 Ω ± 1%, ⅛W.	27–TM4298/2
97	R98	Carbon, High Stability, 167 Ω ± 1%, ⅛W.	27–TM4298/2
98	R99	Carbon, High Stability, 37·5 Ω ± 1%, ⅛W.	25–TM4298/2
99	R100	Carbon, High Stability, 90 Ω ± 2%, ⅛W.	16–TM5552
100	R101	Carbon, High Stability, 90 Ω ± 2%, ⅛W.	16–TM5552
101	R102	Carbon, High Stability, 360 Ω ± 1%, ⅛W.	17–TM5552
102	R103	Carbon, High Stability, 37·5 Ω ± 5%, ⅛W.	10–TM5551
103	R104	Carbon, High Stability, 75 Ω ± 5%, ⅛W.	11–TM5551
104	R105	Carbon, High Stability, 14·5 Ω ± 5%, ⅛W.	12–TM5551
105	R106	Composition, 560 Ω ± 10%, ¼W.	PC66609/16

** Nominal value; actual value determined during calibration.*

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
106	R107	Composition, 22 kΩ ± 10%, ¼W.	PC66609/35
107	R108	Composition, 1 MΩ ± 10%, ¼W.	PC66609/55
108	R109	Composition, 2·2 kΩ ± 10%, ¼W.	PC66609/23
109	R110	Composition, 100Ω ± 10%, ¼W. (Part of Item 231)	PC66609/7
110	R111	Composition, 10 kΩ ± 10%, ¼W.	PC66609/31
111	R112	Wire-wound, 50 kΩ, Variable, 2W.	81–TF995A/2
112	R113	Composition, 68 kΩ ± 10%, 1W.	57–TF995A/2
113	R114	Composition, 100 kΩ ± 10%, ½W.	PC66611/49
114	R115	Composition, 1 kΩ ± 10%, ¼W.	PC66609/33
115	R116	Composition, 330Ω*, ¼W.	PC66609/13
116	R117	Composition, 2·2 kΩ ± 10%, ¼W.	PC66609/23
117	R118	Composition, 22 kΩ ± 10%, ½W.	PC66611/41
118	R119	Composition, 68 kΩ ± 10%, ¼W.	PC66609/41
119	R120	Composition, 33 kΩ ± 10%, ¼W.	PC66609/37
120	R121	Wire-wound, 950Ω ± 10%, 1W.	82–TF995A/2
121	R122	Composition, 33 kΩ ± 10%, ¼W.	PC66609/43
122	R123	Composition, 470Ω ± 10%, ½W.	PC66611/23
123	R124	Wire-wound, 25Ω, Variable, ½W.	130–TM4826/2

** Nominal value; actual value determined during calibration.*

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		CAPACITORS	
124	C1	Paper, 0·1 μF ± 20%, 350 V d.c.	PC19202/14
125	C2	Paper, 0·1 μF ± 20%, 350 V d.c.	PC19202/14
126	C3	Mica, Special Assembly, 100 μμF, Nominal.	2–TM4826/2
127	C4	Mica, 100 μμF ± 10%, 350 V d.c.	117–TM4826/2
128	C5	Mica, 100 μμF ± 10%, 350 V d.c.	117–TM4826/2
129	C6	Paper, 0·02 μF*, 350 V d.c.	12–TM4800/2
130a	C7	Ceramic, 22 μμF ± 5%, 750 V d.c.	71–TM4826/2
131	C8	Mica, 100 μμF ± 10%, 350 V d.c.	95–TF995A/2
132	C9	Mica, 100 μμF ± 20%, 350 V d.c.	86–TF995A/2
133	C10	Mica, Special Assembly, 100 μμF, Nominal.	2–TM4826/2
134	C12	Mica, Special Assembly, 100 μμF, Nominal.	2–TM4826/2
135	C13	Mica, 100 μμF ± 10%, 350 V d.c.	117–TM4826/2
136	C14	Paper, 2 μF ± 25%, 250 V d.c.	87–TF995A/2
137	C15	Paper, 0·01 μF ± 20%, 350 V d.c.	13–TM4800/2
138	C16	Paper, 0·01 μF ± 25%, 350 V d.c.	15–TM4800/2
139	C17	Paper, 0·1 μF ± 20%, 350 V d.c.	PC19202/14
140	C18	Paper, 0·1 μF ± 20%, 350 V d.c.	PC19202/14
141	C19	Mica, Special Assembly, 100 μμF, Nominal.	3–TM4826/2
142	C20	Ceramic, 0·01 μF − 20% + 100%.	135–TM4826/2
143	C21	Ceramic, 0·001 μF ± 20%, 400 V d.c. (Included in Item 214)	12–TM3900/75
144	C22	Mica, Special Assembly, 100 μμF, Nominal. (Included in Item 214)	9–TM3900/75
145	C23	Mica, 100 μμF ± 10%, 350 V d.c.	86–TM4826/2
146	C24	Paper, 0·001 μF ± 20%, 600 V d.c.	91–TM4826/2
147	C25	Mica, 39 μμF ± 5%, 350 V d.c.	85–TM4826/2
148	C26	Paper, 0·1 μF ± 20%, 350 V d.c.	PC19202/14
149	C27	Paper, 0·001 μF ± 20%, 600 V d.c.	91–TM4826/2
150	C28	Paper, 0·01 μF ± 20%, 350 V d.c.	83–TM4826/2
151	C29	Mica, 47 μμF ± 20%, 350 V d.c. (Included in Item 215)	9–TM3900/74
152	C30	Ceramic, 4·7 μμF ± 20%, 500 V d.c. Temperature Compensation, (−3000 ± 10%) × 10^{-6} μμF/μμF/°C.	89–TM4826/2
153	C31	Ceramic, 100 μμF ± 5%, 500 V d.c.	88–TM4826/2
154	C32	Paper, 2 μF ± 25%, 150 V d.c.	151–TM4826/2
155	C33	Ceramic, 1 μμF ± 20%, 500 V d.c.	82–TM4826/2
156		Two-section ganged capacitor complete with trimmers; includes C34, C35, C46 and C47.	TC1478/1
	C34	Air, Variable, 14–200 μμF, part of Item 156.	
	C35	Air, Trimmer, 3–30 μμF, part of Item 156.	
157	C36	Ceramic, 47 μμF ± 20%, 500 V d.c.	76–TM4826/2
158	C37	Paper, 0·1 μF ± 20%, 350 V d.c.	PC19202/14

** Nominal value; actual value determined during calibration.*

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
159	C38	Ceramic, 100 μμF ± 20%, 500 V d.c.	84–TM4826/2
160	C39	Paper, 0·01 μF ± 20%, 350 V d.c.	83–TM4826/2
161	C40	Air, Trimmer, 1·25–10 μμF.	116–TM4826/2
162	C41	Ceramic, 3·3 μμF ± 10%, 750 V d.c.	75–TM4826/2
163	C42	Ceramic, 4700 μμF −0 + 100%, 500 V d.c.	92–TM4826/2
164	C43	Ceramic, 5 μμF ± 20%, 750 V d.c.	134–TM4826/2
165	C44	Ceramic, 10 μμF ± 20%, 750 V d.c.	PC18201/9
166	C45	Paper, 0·5 μF ± 25%, 150 V d.c.	150–TM4826/2
	C46	Air, Variable, 7–100 μμF, part of Item 156.	
	C47	Air, Trimmer, 2–8 μμF, part of Item 156.	
167	C48	Ceramic, 100 μμF ± 20%, 500 V d.c.	84–TM4826/2
168	C49	Ceramic, 22 μμF ± 20%, 500 V d.c.	87–TM4826/2
169	C50	Ceramic, 47 μμF ± 20%, 500 V d.c.	73–TM4826/2
170	C51	Mica, 100 μμF ± 10%, 350 V d.c.	117–TM4826/2
171	C52	Mica, Special Assembly, 100 μμF, Nominal.	4–TM4826/2
172	C53	Electrolytic, 2 μF −20% + 50%, 150 V d.c.	103–TF995A/2
173	C54	Paper, 0·1 μF ± 25%, 250 V d.c.	93–TF995A/2
174	C55	Ceramic, 33 μμF ± 10%, 500 V d.c.	PC18202/7
175	C56	Mica, 100 μμF ± 10%, 350 V d.c.	117–TM4826/2
176	C57	Mica, Special Assembly, 100 μμF, Nominal.	124-127-TM4826/2
177	C58	Electrolytic, 8 μF −20% + 50%, 450 V d.c.	33–TM4299/2
178	C59	Air, Trimmer, 1·25–10 μμF.	116–TM4826/2
179	C60	Ceramic, Stand-off, 820 μμF ± 20%, 750 V d.c.	79–TM4826/2
180	C61	Ceramic, 5 μμF ± 20%, 500 V d.c.	118–TM4826/2
181	C62	Electrolytic, 30 μF −20% + 50%, 350 V d.c.	13–TM4299/2
182	C63	Paper, 0·01 μF ± 20%, 350 V d.c.	83–TM4826/2
183	C64	Ceramic, 100 μμF ± 20%, 750 V d.c.	PC18202/13
184		Three-section ganged capacitor complete with trimmers; includes C65, C66, C75, C76, C81 and C83.	TC21478/2
	C65	Air, Variable, 7–100 μμF; part of Item 184.	
	C66	Air, Trimmer, 2–8 μμF; part of Item 184.	
185	C67	Ceramic, 22 μμF ± 20%, 500 V d.c.	87–TM4826/2
186	C68	Paper, 0·01 μF ± 20%, 350 V d.c.	83–TM4826/2
187	C69 and C71	Electrolytic, Dual Section, 16 μF −20% + 50% 8 μF −20% + 50%, 350 V d.c.	12–TM4299/2
188	C70	Ceramic, 100 μμF ± 20%, 500 V d.c.	84–TM4826/2
	C71	See Item 187.	
189	C72	Ceramic, Stand-off, 820 μμF ± 20%, 750 V d.c.	79–TM4826/2
190	C73	Ceramic, 5 μμF ± 20%, 500 V d.c.	118–TM4826/2

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
191	C74	Ceramic, 100 μμF ± 20%, 750 V d.c.	PC18202/13
	C75	Air, Variable, 7–100 μμF, part of Item 184.	
	C76	Air, Trimmer, 2–8 μμF, part of Item 184.	
192	C77	Ceramic, 10 μμF ± 20%, 500 V d.c.	80–TM4826/2
193	C78	Ceramic, 100 μμF ± 20%, 500 V d.c.	84–TM4826/2
194	C79	Paper, 6 μF ± 20%, 150 V d.c.	79–TF995A/2
195	C80	Ceramic, 100 μμF ± 20%, 750 V d.c.	PC18202/13
	C81	Air, Variable, 7–75 μμF, part of Item 184.	
196	C82	Ceramic, Stand-off, 820 μμF ± 20%, 750 V d.c.	79–TM4826/2
	C83	Air, Trimmer, 2–8 μμF, part of Item 184.	
197	C84	Paper, 100 μμF ± 20%, 300 V a.c.	80–TF995A/2
198	C85	Paper, 100 μμF ± 20%, 300 V a.c.	80–TF995A/2
199	C86	Paper, 100 μμF ± 20%, 300 V a.c.	80–TF995A/2
200	C87	Paper, 100 μμF ± 20%, 300 V a.c.	80–TF995A/2
201	C88	Ceramic, 820 μμF ± 20%, 350 V d.c.	41–TM4297A
202	C89	Ceramic, 820 μμF ± 20%, 350 V d.c.	41–TM4297A
203	C90	Ceramic, 820 μμF ± 20%, 350 V d.c.	41–TM4297A
204	C91	Paper, 0·1 μF ± 20%, 350 V d.c.	PC19202/14
205	C92	Paper, 0·25 μF ± 20%, 500 V d.c.	32–TM4299/2
206	C93	Ceramic, 15 μμF ± 20%, 500 V d.c.	119–TM4826/2
207	C94	Ceramic, 120 μμF ± 10%, 750 V d.c.	74–TM4826/2
208	C95	Ceramic, 68 μμF ± 10%, 750 V d.c.	90–TM4826/2
209	C96	Ceramic, 3·3 μμF ± 10%, 750 V d.c.	75–TM4826/2
209/1	C97	Electrolytic, 25 μF — 20% + 100%, 12 V d.c.	68-TF995A/2

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		INDUCTORS	
210	L1	R.F. Filter Inductor.	TM4087/14
211	L2	R.F. Filter Inductor.	TM4087/14
212	L3	R.F. Inductor.	TB16363/27
213	L4	R.F. Filter Inductor.	TM4087/14
214		Main portion of three-section filter assembly; includes L6 and L7, and Items 143 and 144.	TM3900/75
	L6	R.F. Filter Inductor; part of Item 214.	
	L7	R.F. Filter Inductor; part of Item 214.	
215	L8	Screened R.F. Inductor Assembly; includes Item 151.	TM3900/74
216	L9	Modulation Choke.	TM4159/1
217	L10	30-Mc/s Oscillator Inductor.	TB23173/1
218	L11	Screened R.F. Inductor Assembly.	TM4087/14
219	L14	R.F. Inductor.	TB23173/3
220	L15	R.F. Inductor.	TB23173/4
221	L16	H.T. Smoothing Choke.	TM5172/31
222	L17	H.T. Smoothing Choke.	TM5172/31
223	L18	Multiplier Tuning Inductor, 27–55 Mc/s.	TA22011
	L19	R.F. Inductor; part of Item 61.	TB23173/10
	L21	R.F. Inductor; part of Item 55.	TB23173/9
224	L22	Multiplier Tuning Inductor, 54–110 Mc/s.	TB20309/1
225	L23	Multiplier Tuning Inductor, 108–220 Mc/s.	TE23048/11
226	L24	R.F. Inductor (mains filter).	TA14323/18
227	L25	R.F. Inductor (mains filter).	TA14323/18
228	L26	Filter Inductor.	TB23173/39
		TRANSFORMERS	
229	T1	A.F. Oscillator Transformer.	TM4085/2
230	T2	Master Oscillator R.F. Transformer, 4·5–9 Mc/s.	TM3900/87
231	T3	Multiplier R.F. Transformer, 13·5–27 Mc/s. (Includes Items 29 and 109)	TM3900/52
232	T4	Mains Transformer.	TM5150/25
233	T5	R.F. Output Transformer, 2–13·5 Mc/s.	TB23173/5

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		SWITCHES	
234	S1	Rotary, 8 pole, 5 position, 4 wafer.	TC4428/373
235	S2	Rotary, 10 pole, 5 position, 4 wafer.	TC4428/366
236	S3	Lever-Actuated Rotary, 2 pole, 3 position, 2 wafer, biased to mid-position; includes bakelite handle.	TC4428/342
237	S4	Toggle, 2 pole, 2 position.	TB23903/2
238	S5	Rotary, 2 pole, 2 position, single wafer.	96–TM4826/2
239	S6	Rotary, 4 pole, 2 position, single active wafer, with extra dummy wafer.	TC4428/344
240	S7	Toggle, 2 pole, 2 position.	TB23903/2
		VALVES, VALVE HOLDERS, AND RETAINERS	
241	V1	6AK6, Pentode.	47–TF995A/2
242		Holder, for V1.	TB26904/2
243		Retainer, for V1.	PC17501/2
244	V2	6AK6, Pentode.	100–TM4826/2
245		Holder, for V2.	TB26904/2
246		Retainer, for V2.	PC17501/2
247	V3	6AK5, Pentode.	101–TM4826/2
248		Holder, for V3.	TB26904/2
249		Retainer, for V3.	PC17501/1
250	V4	6AK5, Pentode.	101–TM4826/2
251		Holder, for V4.	TB26904
252		Retainer, for V4.	PC17501/1
253	V5	6AU6, Pentode.	49–TF995A/2
254		Holder, for V5.	TB26904/2
255		Retainer, for V5.	PC17501/2
256	V6	6AK5, Pentode.	101–TM4826/2
257		Holder, for V6.	TB26904
258		Retainer, for V6.	PC17501/1
259	V7	12AT7, Double Triode.	103–TM4826/2
260		Holder, for V7.	TB26905/2
261		Retainer, for V7.	PC17502/2
262	V8	6AK5, Pentode.	101–TM4826/2
263		Holder, for V8.	TB26904
264		Retainer, for V8.	PC17501/1
265	V9	OA2, Voltage Stabilizer.	48–TF995A/2

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
266		Holder, for V9.	TB26904/2
267		Retainer, for V9.	PC17501/2
268	V10	6AK5, Pentode.	101–TM4826/2
269		Holder, for V10.	TB26904
270		Retainer, for V10.	PC17501/1
271	V11	5Z4G, F.W. Rectifier.	16–TM4299/2
272		Holder, for V11.	PC81814/1
273		Retainer, for V11.	TC22744/12
274	V12	6AK5, Pentode.	101–TM4826/2
275		Holder, for V12.	TB26904
276		Retainer, for V12.	PC17501/1
277	V13	6AL5, Double Diode.	46–TF995A/2
278		Holder, for V13.	TB26904/2
279		Retainer, for V13.	PC17501/2
280	V14	5651, Voltage Stabilizer.	20–TM4299/2
281		Holder, for V14.	TB26904/2
282		Retainer, for V14.	PC17501/2
283	V15	6AL5, Double Diode.	21–TM4299/2
284		Holder, for V15.	TB26904/2
285		Retainer, for V15.	PC17501/1
		CRYSTALS	
286	X1	Quartz Oscillator Crystal, 333·33 kc/s.	102–TM4826/2
287		Holder, for X1.	98–TM4826/2
288		Retainer, for X1.	99–TM4826/2
289	X2	CS2A, Silicon Rectifier.	40–TM4297/2
290		Retaining Contact, for X2.	TD20400/7
		LAMP	
291	PL1	Pilot Lamp, 6·5 V, 0·3 A, M.E.S.	32–TF995A/2
292		Pilot Lamp Holder, with Red Lens.	42–TF995A/2
		FUSES AND HOLDERS	
292/1	FS1	150-mA cartridge fuse	57-TM4299/2
292/2	FS2/FS3	2-amp cartridge fuses	58-TM4299/2
292/3	FS2/FS3	3-amp cartridge fuses (for use on 100 to 150 volts range only)	
292/4		Holder, for cartridge fuses	59-TM4299/2

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		METER	
293	M1	0–100 μA, 500 Ω Nominal, Moving Coil, including clamping brackets.	TM3970/30
		PLUGS, SOCKETS, AND CONNECTING LEADS	
294	P1	Plug, 6-way.	18–TM4299/2
295	SK1	Socket, 6-way.	55–TF995A/2
296		Mains Lead comprising 6-ft, 3-core Flexible Cable and 3-pin plug complete with Plastic Entry Sleeve.	TM2560AQ
297		75 Ω Type BNC Socket, coaxial, free.	30–TM4298/1
298		75 Ω Type BNC Socket, coaxial, fixed.	6–TM5551
299		50 Ω Type BNC Socket, coaxial, fixed.	7–TM5551
300		75 Ω Type BNC Plug (modified), coaxial, fixed.	8–TM5551 TC27665 TB26997/1
301		R.F. Output Cable, coaxial, 4 ft 6 in; includes Item 297.	38–TM4298/1
302	J1	CRYSTAL CHECK Jack, including Telephone Plug.	54–TF995A/2
303		Bush, for Item 302.	TA19742
		KNOBS, DRIVES, AND DIALS	
304		Knobs, for TUNE and INC. FREQ. controls.	TB29569
305		TUNE control dial.	TC20320/4
306		INC. FREQ. control dial.	TB23220
307		Set of three Special Screws for fixing dials to knobs.	TA4014
308		Cursors, for TUNE and INC. FREQ. Dials.	TA20308
309		FREQUENCY DIAL. Pre-calibrated.	TB23189
310		Dial Escutcheon Mounting Ring.	TD20670/2
311		Dial Escutcheon (Chromium Plated), with Rubber Tubing Gasket, to fit over Item 310.	TD20670/1 8–TM4357/2
312		Window, including Movable Cursor Assembly, to fit in Item 311.	TC20735/2 TD20670/3 TA20726 TB6775/300 6–TM4357
313		Nylon Drive Cord.	12–TM4826/2
314		Knob, for MOD SELECTOR switch, S1.	TB25460/2
315		Knob, for RANGE MC/S switch, S2.	TB25460/2
316		Knob, for DEVIATION—NORMAL/HIGH switch, S5.	TB25460/2
317		Knob, for DEVIATION RANGE switch, S6.	TB25460/2
318		Knob, for OUTPUT VOLTAGE attenuator.	TB17848/3
319		Knob, for MULTIPLY BY attenuator.	TB17848/3
320		Knob, for SET CARRIER control, R44.	TB23920/1
321		Knob, for SET MOD control, R25.	TB23920/1

SOS Item No.	*Circuit Ref.*	*Description*	*Works Ref.*
		MISCELLANEOUS	
322		Cover Plate, for R.F. Output Cable exit, in Right-Hand Handle Recess.	TA19721
323		Grommet, to fit in Item 322.	TA6515/1
324		Cable Saddle, to secure Item 301 to Item 322.	29–TF995A/2
325		Front Panel.	TD22009/2A
326		Set of Eight Screws, complete with Black Fibre Washers for fixing Front Panel to case.	30–TF995A/2 TB6775/183
327		Terminal, EXT MOD.	TB24330/5
328		Terminal, SYNC.	TB24330/5
329		Terminal, EARTH.	TB24330/5
330		Case Assembly complete with Handles and Feet.	TM4310 TB18258 TA11420
331		Handle Escutcheon. Two included in Item 330.	TB18258
332		Case Foot. Four included in Item 330.	TA11420
333		20-dB Step Attenuator Assembly; includes Items 70 to 81 inclusive, 201, 202, 203, 289, and 290.	TM4297A
334		2-dB Step Attenuator Assembly; includes Items 82 to 98 inclusive.	TM4298
335		20-dB ATTENUATOR PAD; includes Items 99 to 101 inclusive, and Items 298 and 300.	TM5552
336		52- and 75-ohm TERMINATING UNIT; includes Items 102 to 104 inclusive, and Items 298 to 300 inclusive.	TM5551
337		R.F. Unit Screening Cover.	TD20318 26A–TM4826
338		Contact Spring for earthing R.F. Unit Screening Cover.	TC–20321/3E
339		Set of three Hexagonal Wrenches for Socket Set Screws, sizes 2, 4, and 6BA; complete in linen bag.	104–TF995A/2
340		Operating and Maintenance Handbook.	OM995A/2M

Decibel Conversion Table

Ratio Down			Ratio Up	
VOLTAGE	POWER	DECIBELS	VOLTAGE	POWER
1·0	1·0	**0**	1·0	1·0
·9886	·9772	**·1**	1·012	1·023
·9772	·9550	**·2**	1·023	1·047
·9661	·9333	**·3**	1·035	1·072
·9550	·9120	**·4**	1·047	1·096
·9441	·8913	**·5**	1·059	1·122
·9333	·8710	**·6**	1·072	1·148
·9226	·8511	**·7**	1·084	1·175
·9120	·8318	**·8**	1·096	1·202
·9016	·8128	**·9**	1·109	1·230
·8913	·7943	**1·0**	1·122	1·259
·8710	·7586	**1·2**	1·148	1·318
·8511	·7244	**1·4**	1·175	1·380
·8318	·6918	**1·6**	1·202	1·445
·8128	·6607	**1·8**	1·230	1·514
·7943	·6310	**2·0**	1·259	1·585
·7762	·6026	**2·2**	1·288	1·660
·7586	·5754	**2·4**	1·318	1·738
·7413	·5495	**2·6**	1·349	1·820
·7244	·5248	**2·8**	1·380	1·905
·7079	·5012	**3·0**	1·413	1·995
·6683	·4467	**3·5**	1·496	2·239
·6310	·3981	**4·0**	1·585	2·512
·5957	·3548	**4·5**	1·679	2·818
·5623	·3162	**5·0**	1·778	3·162
·5309	·2818	**5·5**	1·884	3·548
·5012	·2512	**6**	1·995	3·981
·4467	·1995	**7**	2·239	5·012
·3981	·1585	**8**	2·512	6·310
·3548	·1259	**9**	2·818	7·943
·3162	·1000	**10**	3·162	10·000
·2818	·07943	**11**	3·548	12·59
·2512	·06310	**12**	3·981	15·85
·2239	·05012	**13**	4·467	19·95
·1995	·03981	**14**	5·012	25·12
·1778	·03162	**15**	5·623	31·62

DECIBEL CONVERSION TABLE

Ratio Down			*Ratio Up*	
VOLTAGE	*POWER*	*DECIBELS*	*VOLTAGE*	*POWER*
·1585	·02512	**16**	6·310	39·81
·1413	·01995	**17**	7·079	50·12
·1259	·01585	**18**	7·943	63·10
·1122	·01259	**19**	8·913	79·43
·1000	·01000	**20**	10·000	100·00
·07943	·006310	**22**	12·59	158·5
·06310	·003981	**24**	15·85	251·2
·05012	·002512	**26**	19·95	398·1
·03981	·001585	**28**	25·12	631·0
·03162	·001000	**30**	31·62	1,000
·02512	·0006310	**32**	39·81	1,585
·01995	·0003981	**34**	50·12	2,512
·01585	·0002512	**36**	63·10	3,981
·01259	·0001585	**38**	79·43	6,310
·01000	·0001000	**40**	100·00	10,000
·007943	·00006310	**42**	125·9	15,850
·006310	·00003981	**44**	158·5	25,120
·005012	·00002512	**46**	199·5	39,810
·003981	·00001585	**48**	251·2	63,100
·003162	·00001000	**50**	316·2	100,000
·002512	$6{\cdot}310 \times 10^{-6}$	**52**	398·1	158,500
·001995	$3{\cdot}981 \times 10^{-6}$	**54**	501·2	251,200
·001585	$2{\cdot}512 \times 10^{-6}$	**56**	631·0	398,100
·001259	$1{\cdot}585 \times 10^{-6}$	**58**	794·3	631,000
·001000	10^{-6}	**60**	1,000	10^{6}
·0005623	$3{\cdot}162 \times 10^{-7}$	**65**	1,778	$3{\cdot}162 \times 10^{6}$
·0003162	10^{-7}	**70**	3,162	10^{7}
·0001778	$3{\cdot}162 \times 10^{-8}$	**75**	5,623	$3{\cdot}162 \times 10^{7}$
·0001000	10^{-8}	**80**	10,000	10^{8}
·00005623	$3{\cdot}162 \times 10^{-9}$	**85**	17,780	$3{\cdot}162 \times 10^{8}$
·00003162	10^{-9}	**90**	31,620	10^{9}
·00001000	10^{-10}	**100**	100,000	10^{10}
$3{\cdot}162 \times 10^{-6}$	10^{-11}	**110**	316,200	10^{11}
10^{-6}	10^{-12}	**120**	10^{6}	10^{12}
$3{\cdot}162 \times 10^{-7}$	10^{-13}	**130**	$3{\cdot}162 \times 10^{6}$	10^{13}
10^{-7}	10^{-14}	**140**	10^{7}	10^{14}

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